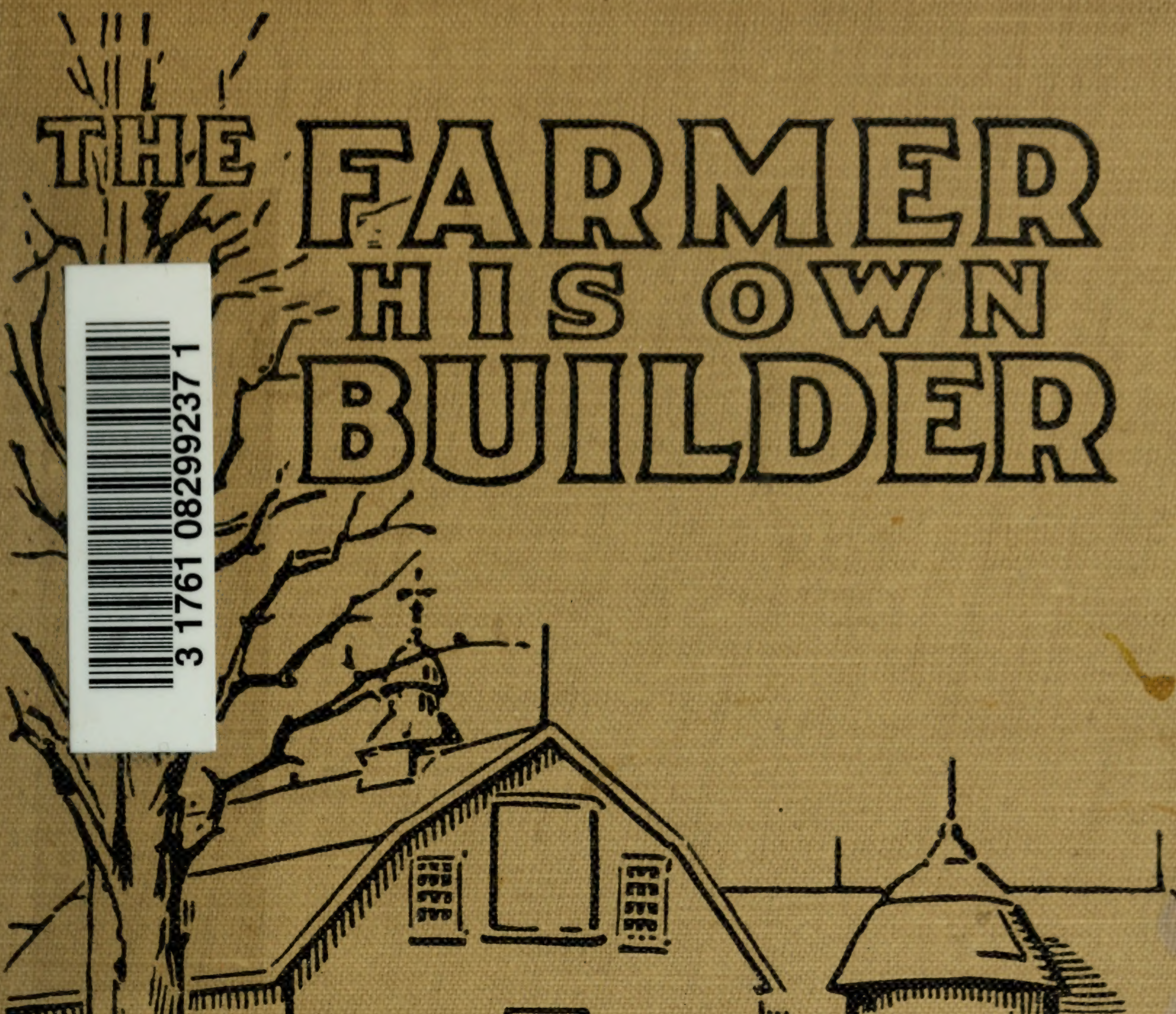
THE FARMER HIS OWN BUILDER



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H. ARMSTRONG ROBERTS

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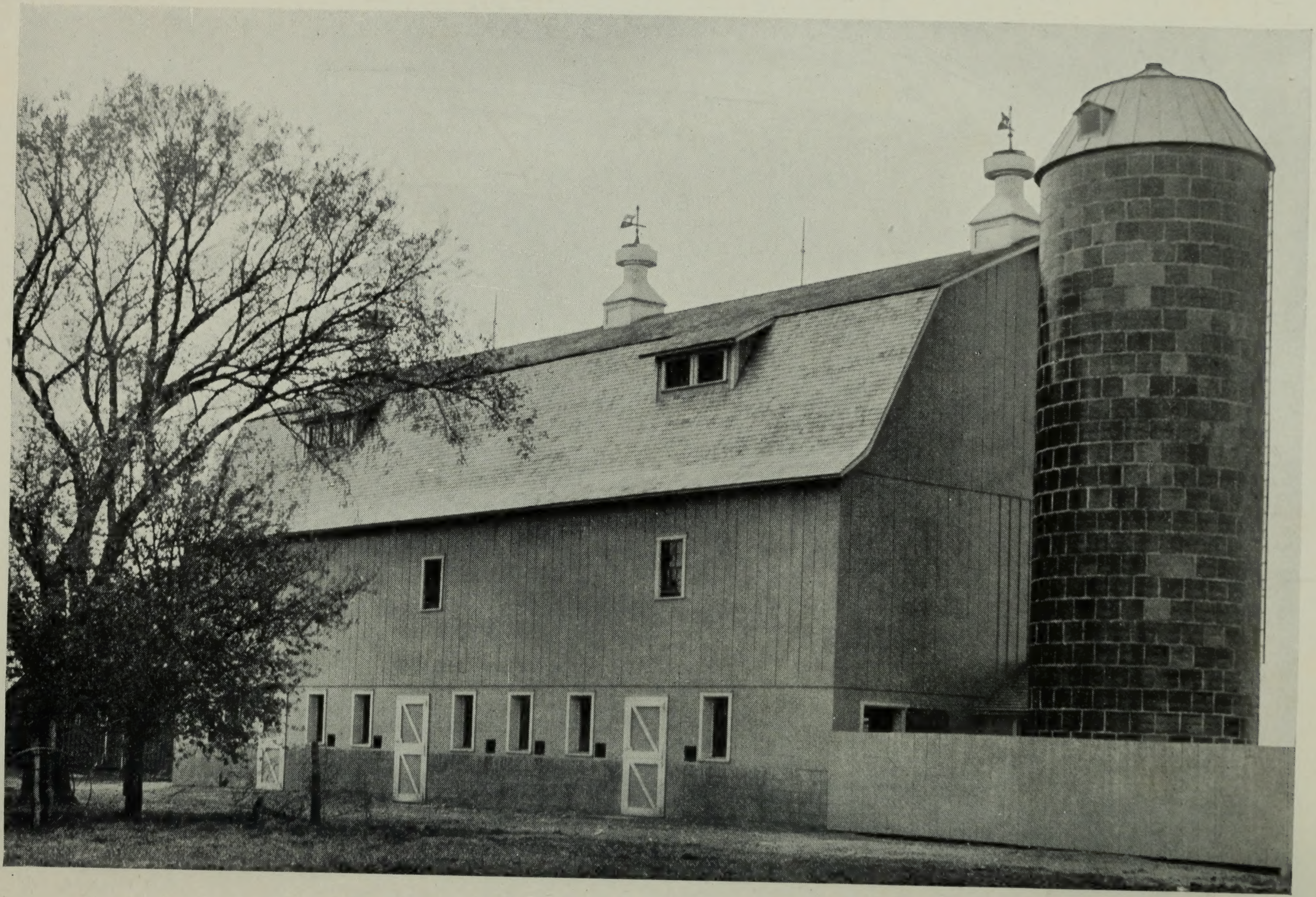

Gambrel roof, concrete basement dairy barn with tile silo

The Farmer His Own Builder

A Guide and Reference Book

FOR THE

Construction of Dwellings, Barns and other Farm Buildings, together with their Utilities

Describing Reliable Methods, Offering Practical Suggestions, Presenting Numerous Details and Formulas, and Explaining Simple Rules for Estimating the Labor and Materials Required. With Special Reference to Concrete and Carpentry.

BY

H. ARMSTRONG ROBERTS

CONTAINING OVER 170 ILLUSTRATIONS MOSTLY BY THE AUTHOR.

PHILADELPHIA
DAVID McKAY, Publisher
608 South Washington Square

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To
My Sons
with the hope that they will attain
manhood as proficient mechanics this work is
affectionately inscribed.

FULL PAGE ILLUSTRATIONS

Gambrel-roof, Concrete Basement Dairy Barn with Tile Silo .... *Frontispiece.*

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PREFACE

The object of this book is to furnish a practical guide and reference for those who would undertake their own building improvements, but who are handicapped more or less by a limited knowledge of building construction. Its topics are prepared especially for the farmer, and deal almost exclusively with the erection of country dwellings, barns, and other farm buildings, together with their utilities.

Numerous works are available which have to do with all kinds of structural and mechanical subjects. Most of them, however, are prepared in a strictly technical vein, consequently, though of unquestioned value to the experienced mind, they must necessarily appeal to specialists—those having considerable previous knowledge of the subjects—to be clearly understood.

In planning the present book the writer has kept in mind the needs of the farmer of limited capital, who, when he builds or improves, is obliged to make every dollar exert the greatest possible value. Wealthy men who operate farms as hobbies may hire architects, contractors, and other experts to erect ideal buildings and equipment regardless of cost. The average farmer is usually his own architect and frequently his own builder. In most cases the village carpenter is his only available authority, and to intrust him with the task of originating important details relating to the most improved agricultural practices, concerning which he probably has no particular interest or ability, is to invite unsatisfactory if not extremely costly results.

Economy and efficiency have been kept paramount throughout the succeeding pages. Conditions and requirements, of course, are so varied it is not likely that the work can be followed in its entirety. Its aim is rather to serve as a reminder and suggestion, which may be modified to meet individual requirements. Particular attention has been paid to the inventions and improvements of the past few years, so that the work should present a complete summary of the most progressive ideas. It is hoped that the descriptive portions have been greatly enhanced and clarified by the introduction of numerous drawings throughout the text.

The author desires to acknowledge his obligation to the Editors of The Country Gentleman, in which publication most of the following chapters have appeared in the form of separate articles.

Acknowledgment is also made for the use of plans of barns and other buildings appearing in various bulletins published by the United States Department of Agriculture and State Experiment Stations.

PHILADELPHIA, 1918. H. ARMSTRONG ROBERTS.

NOTE.—The prices and estimates mentioned throughout this work are based on the costs of materials and labor which prevailed before the outbreak of the European War.—H. A. R.

The Farmer His Own Builder

CHAPTER I

POINTS ON PREPARING PLANS, SPECIFICATIONS, AND TAKING BIDS

A GOOD farm is worth good buildings.

The strongest argument in favor of this statement is a visit to a well-managed stock farm. Farming is as much a business as the manufacture of shoes, soap, nails, litter carriers, or any other commodity. Its measure of success depends upon the extent to which correct principles and methods are applied to its management. Naturally, the methods will vary according to location and climate, yet the underlying principles are the same. The most successful system of farming is that which yields the largest profit; at the same time it allows the workers their full share of health and happiness, and leaves the soil in prime condition to produce subsequently profitable crops.

Climate, soil conditions, proximity to markets, availability of farm labor, land values, and social conditions are all problems for the farmer to consider; but none are more worthy than the style and arrangement of the farm buildings. Conservation of time and labor is the really important feature.

Many farmers feel that certain improvements are necessary, yet they hesitate to undertake them on account of the expense. Usually this is the wrong attitude. Necessary improvements are not to be reckoned as an expense. They are an investment—economy. Economy in business often means spending money. The point is to spend the money wisely, so that it will soon be returned, with interest.

Farm buildings constitute the farmer's factory; the implements—plow, harrow, thresher, cultivator, sprayer, planter, and so on—are his machinery; his horses, mules, cows, hogs, chickens, and other livestock represent his laborers; and his raw materials are those he obtains from the soil in the form of grain, hay, and other crops. These raw materials are taken to the farm's shops and converted into high-priced butter, beef, pork, and mutton; hence it behooves the farmer to have his workshops built along the most improved, labor-saving principles, sanitary and healthful.

If only our forefathers had given a little more thought to the comfort and well-being of their stock and farm help, they wouldn't have had such a struggle to get along. Most of their buildings were of little service except as store-houses, and even then many were virtually useless.

Every year more attention is given to the construction of factories. Today manufacturers enlist the services of high-salaried architects and engineers, expert authority, to solve the many problems of machinery spaces, transmission of power, heating, lighting, ventilating, and facilities for increased efficiency generally. It is no less important that the farmer should plan his factory with the same degree of careful study. Centralization is a vital consideration. Buildings should be grouped so that the farmer or his helpers may perform their work with the least amount of labor, and as comfortably as possible in any kind of weather.

If tables were compiled showing how much time and labor is needlessly expended on archaic, obsolete methods of conducting agricultural work the figures would stagger the most inveterate plodder.

The trouble with some of us is we don't do any thinking; we have no imagination; we can't see beyond tomorrow. On the other hand, some of us do our thinking too quickly; we jump at conclusions. And both are wrong. We should devote plenty of time to preliminary plans. A good plan is to make a rough map of the intended project, sketching in the buildings, paying particular attention to their different exposures and to drainage, also the relation of each building to the other and to yards and pasture. (See Fig. 1.) Forethought in the beginning will save a lot of trouble and expense in the farm's operation.

You may ask if it will pay to do your own building. It all depends upon circumstances, of which you alone are the best judge.

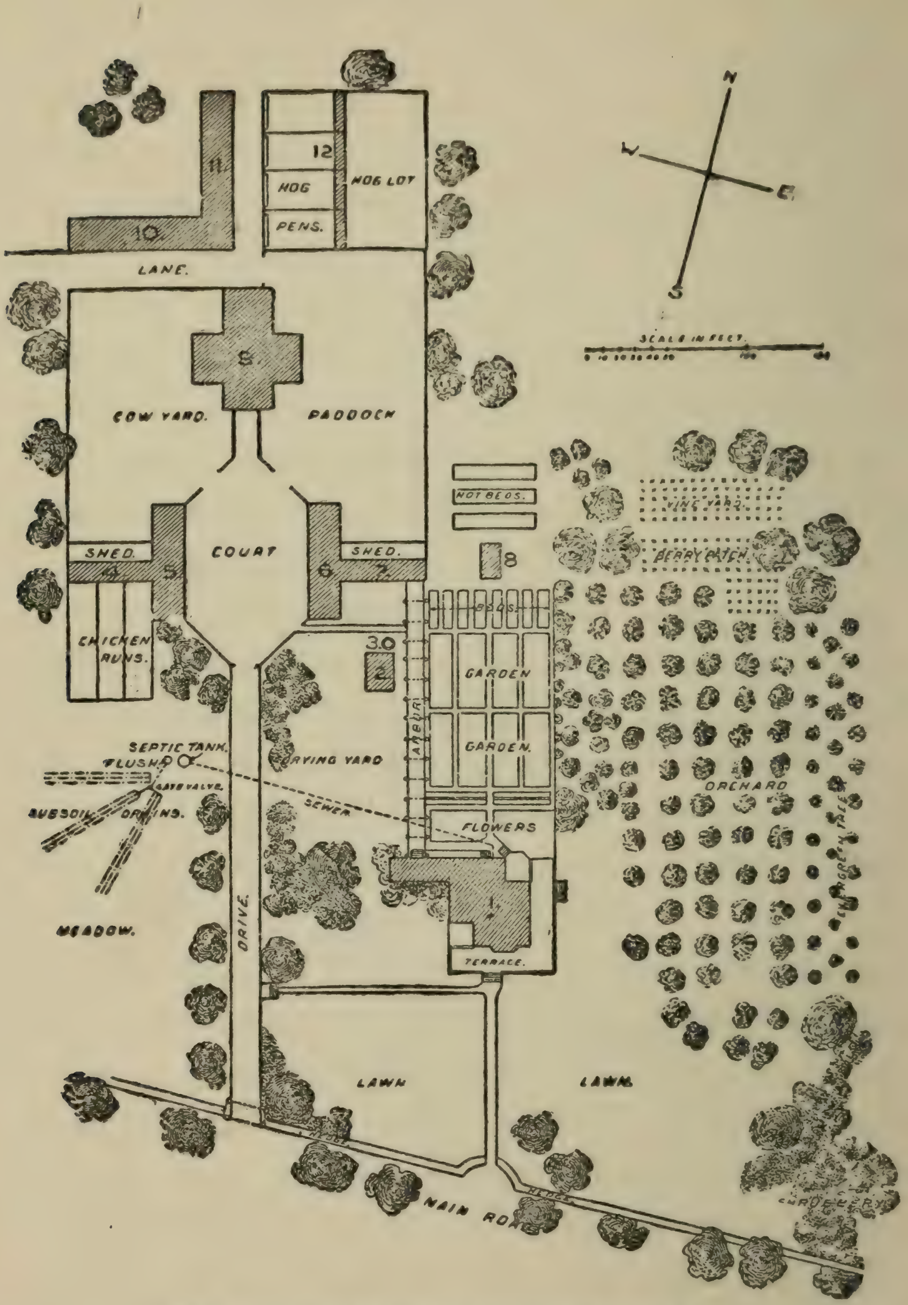


Fig. 1.—General plan for farm-house grounds.

In the first place, yours is not a makeshift job. It is a permanent undertaking; you are building for posterity as well, and as such it is worthy of the best you can afford. You will have to consider the time it takes to lay out the work and for general supervision. As a rule, workmen, such as carpenters and masons, are employed to execute the work, not to originate it. Therefore, you must ask yourself if you have the executive and mechanical ability to put through a first-class job, not to forget the experience necessary to buy the right materials, in the right quantities, at the right time, and at the right prices.

One thing is certain, whether you do the actual building yourself or not, you should know how to do it. Every farmer should be mechanic enough to lay out his own buildings and talk intelligently on the subject to others. Otherwise he is at the mercy and caprice of the other fellow's judgment. After all, you know what is best suited to your purpose, though, of course, it always pays to be open to suggestions from those who have made a specialty in a particular kind of construction. In this day and generation most building operations are done on a contract basis, and the best way to let a contract is on a competitive arrangement. In other words, advertise or ask for bids; obtain proposals from all the contractors and builders in your vicinity. You will be surprised to find what better prices you can get.

I think I can anticipate your next question; it's the very point I'm driving at. You are wondering how you can obtain bids on a dairy barn or other building, in which you will be assured of satisfactory workmanship and materials, and a structure erected in accordance with your ideas. That is a simple matter. You can do it in the same manner that the rich banker puts up a large residence, or a real estate company erects an office building, or the Federal authorities build a new post office—by the preparation of plans and specifications describing the operation in detail, which are made a part of a contract between you and the most acceptable bidder. Furthermore, you can place the bidder under bond, to guarantee the satisfactory performance of his work.

For the erection of fine residences, office buildings, and other large edifices it is, of course, customary to engage the services of a competent architect to draw up a set of plans and working details, to write the specifications, take bids, award the contract, and later to superintend the execution of the work. It is easy to understand how a big undertaking like a million-dollar office building necessitates the services of an expert. In the first place, instead of a single contractor on a job of such magnitude, there will probably be twenty contractors, or one general contractor and twenty subcontractors.

There is seldom any need for the farmer to con-

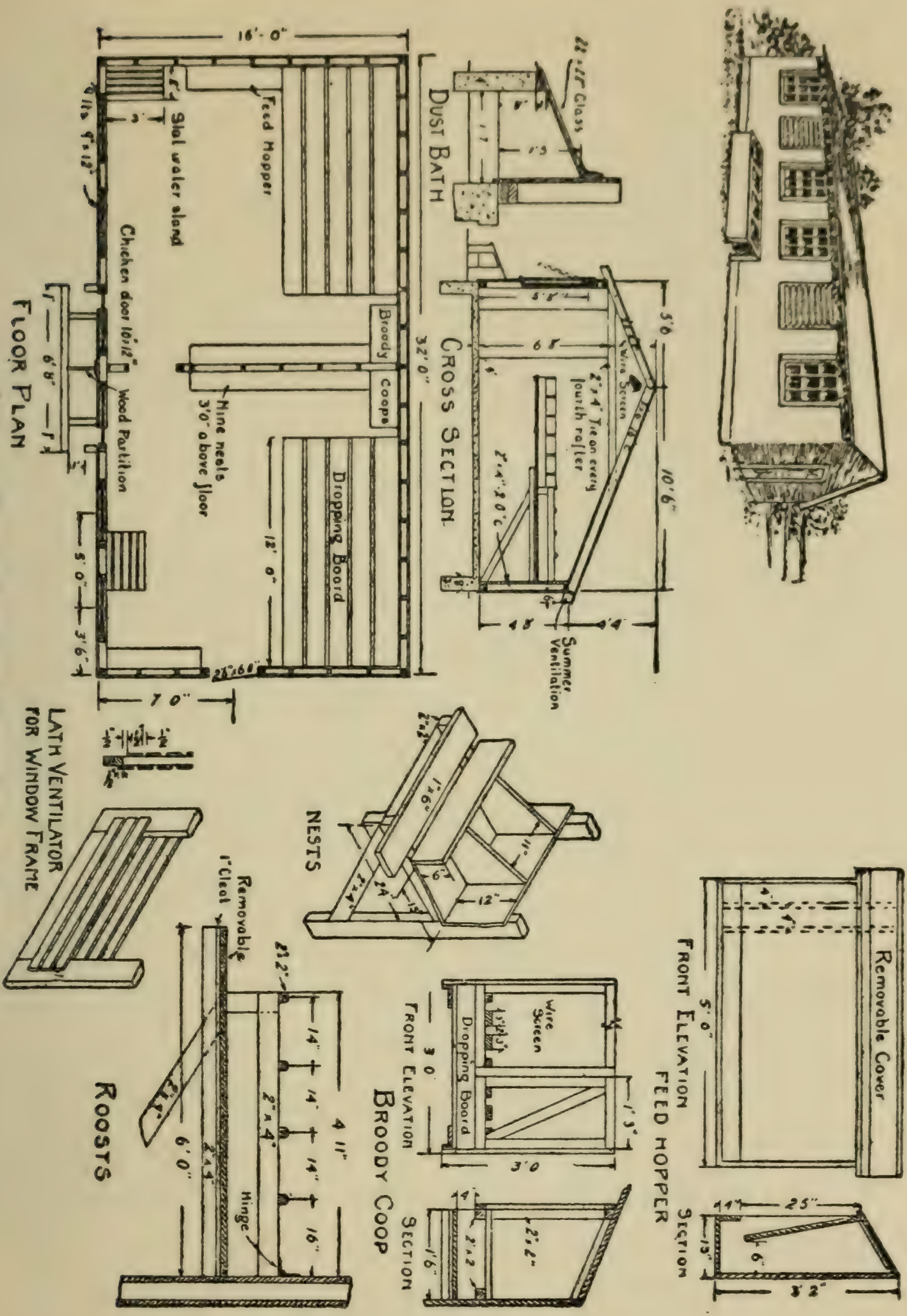


Fig. 2.—Practical poultry house for 125 hens.

sult an architect, any more, perhaps, than to purchase a set of plans for a dwelling or barn, for which there is charged a very nominal price. The architect's services are not required to take bids, award the contract, and then see to it that the successful bidder performs his work properly providing the farmer is sufficiently well versed on such affairs. The charge for these services, which is quite considerable, can be saved.

SPECIFY LABOR AND MATERIALS

Let us review a few of the essential features of a "specification." To build intelligently and profitably it is necessary that the materials and their qualities shall be so designated that there can be no misunderstanding relative thereto either on the part of the owner or the contractor. The real province of the "specification" then is to supplement the drawings by describing those points which cannot be readily expressed by diagrams or figures.

It matters little whether the "specification" has any literary quality, any more than it should deal fully, concisely, and clearly with each part of the work, in proper sequence, which is to say, that it shall commence with the first part of the work, such as the excavation, or general conditions preliminary to the excavation, and pursue the other branches of the work as they would be performed in practice. Remarks referring first to one subject and then to another, without relationship, should be avoided. They tend to confuse rather than to elucidate.

If there is to be a general contractor and under him sub-contractors, then it shall be one of the functions of the "specification" to define the relations between the different parties, the scope of each class of work, the conditions under which the work is to be done, and the materials employed for every purpose. Specifications should never impose conditions on the contractor that are likely to involve him in unlooked-for expense, and they should not be written in a spirit that tends to destroy a feeling of co-operation. The contractor, like ourselves, is a human being and has a living to make. It is rare that a satisfactory result can be obtained from a contractor who is losing money on the job.

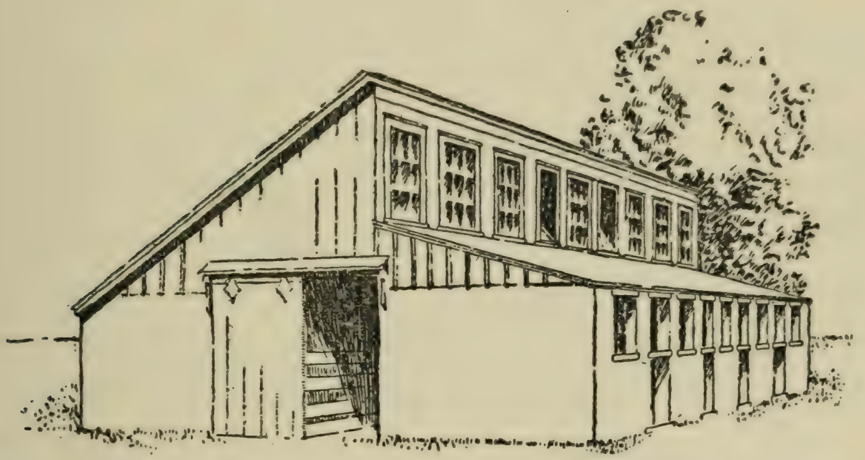


Fig. 3.—Ideal hog house arranged to secure the maximum amount of sunlight.

In writing specifications words should be used in their most common sense, and the language should be intelligible to all persons connected with the work. The specifications should be complete and correct, describing the quality and kind of materials used and the methods of workmanship, but they should not be longer than is absolutely necessary to convey the intended ideas. Accurate specifications save time and trouble for all concerned, but if too verbose they may scare the bidders, which will result in unwarranted high estimates.

In contemplating certain materials, don't feel impelled to call for the best grades of each kind, rather strive to select those that will fully answer the purpose at the least cost. We are accustomed to the expression, "the best is none too good," or that "the best is the cheapest." This may or may not be true. A remark of that kind is often used as cloak for ignorance, or to restrain substitution. In the matter of buying building materials success depends as much on knowing how poor to buy, as how good to buy.

In mentioning materials, they should be treated in classes, care being taken not to detail them in such a way that if for any reason every single point is not covered, such omission can be taken as an excuse by the contractor for an "extra." Materials intended for general use should be described in this way: "All brickwork, not otherwise mentioned, to be laid in a ———."

In preparing a specification it is customary to classify the items under each building trade, and then subdivide the trades as much as necessary. Commence with the general conditions, such as the clauses on drawings, rejected materials, liability insurance, samples, permits, rubbish, scaffolding, and so on; when these are covered, start with the excavation and foundation of the building, and carry the description up through the building to the roof, in the natural order of construction. Describe the kind and class of material to be used on each item, together with the kind of labor to be employed. Generally speaking, the number of pieces and the dimensions are left to the plans, though if the plans are incomplete, owing to a small scale, or if the plan is only a rough sketch, the quantities and sizes will have to be specified more completely.

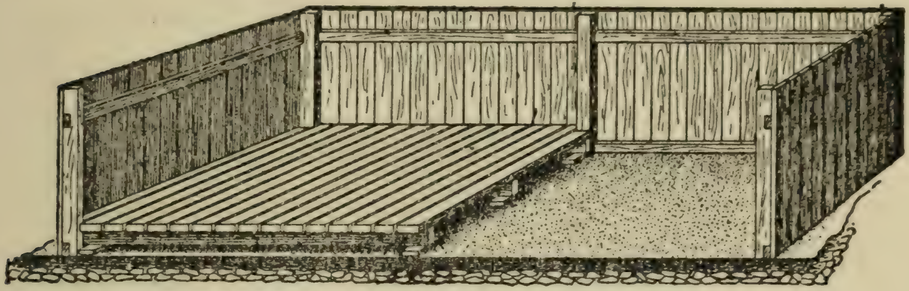


Fig. 4.—Hog pen showing concrete floor with wood overlay.

On certain classes of work the method of writing the specifications can be simplified by referring to State or Municipal building laws, or to regulations recommended by a particular association. Electric wiring, for example, should be done in accordance with the

"Rules and Requirements of the National Board of Fire Underwriters."

TIME OF COMPLETION AND PAYMENT

In addition to the questions relative to labor and material, two other questions always arise in a building operation which may be taken care of in the specifications or left to the contract. These are: When is the work to be completed? What is to be the manner of payment?

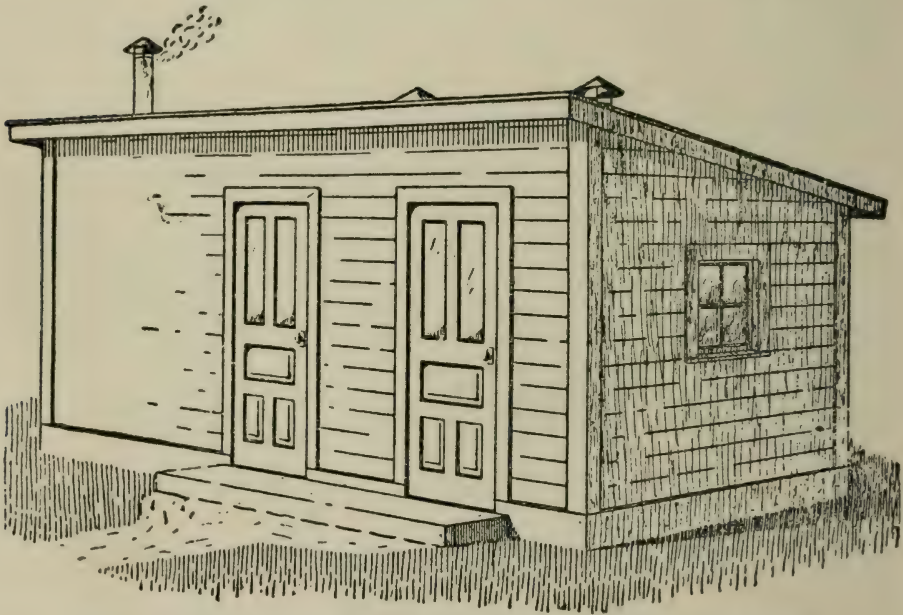


Fig. 5.—Perspective view. Inexpensive, sanitary dairy house.

The periods for completion may be stated in terms of months or days after the signing of the contract and granting of the building permit, if such is required by the local inspectors. It is usually advisable to make some reference to this item in the specifications for information to bidders, also to the terms of payment, as this information often has a marked influence on the estimates.

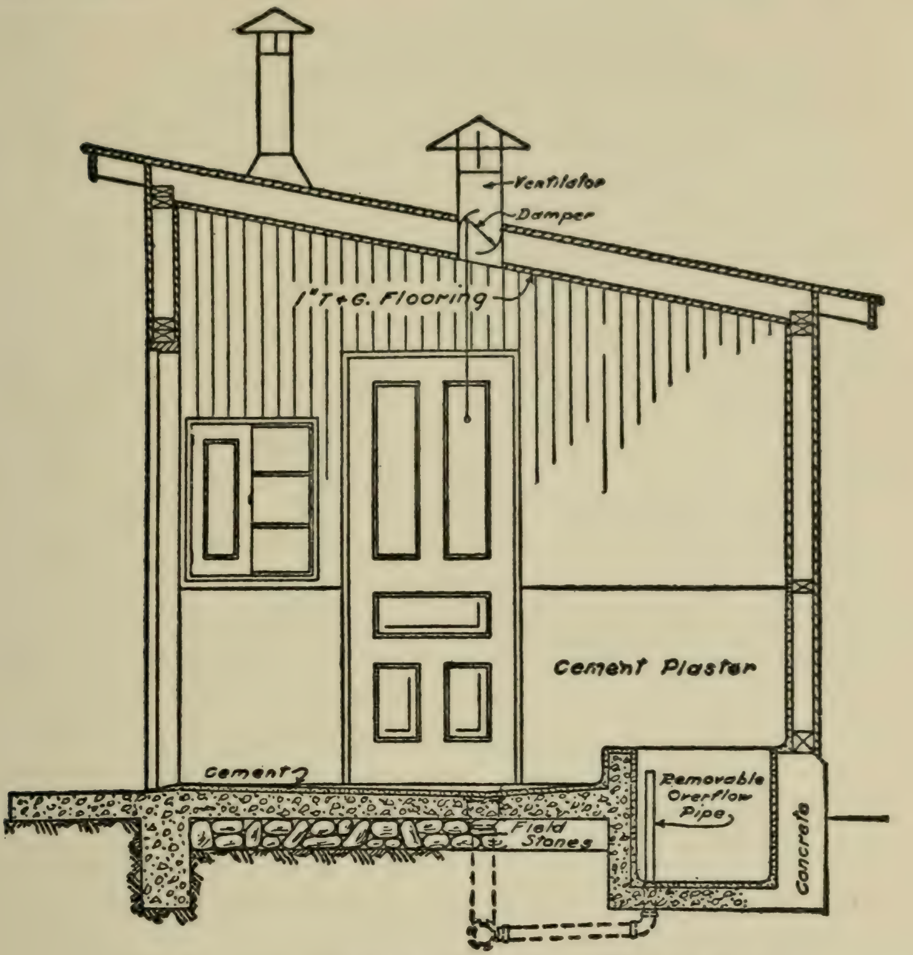


Fig. 6.—Cross-section of dairy house shown in Fig. 5.

Bids may be asked in several ways: (1) A stated lump sum; (2) cost plus a percentage for profit; (3) cost plus a percentage, with a guaranteed limit; (4) cost plus a fixed sum as the profit. The first is the usual method of contracting, and, on the whole, it is the most generally satisfactory.

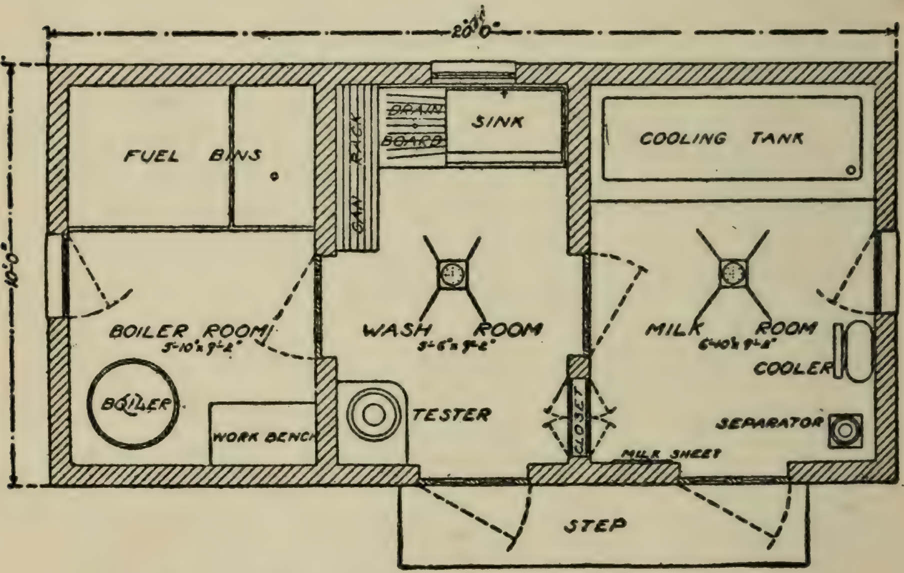


Fig. 7.—Floor plan of dairy house shown in Fig. 5.

The payments should be arranged so as to protect the owner against overpayment before the contract or any part of it is completed, yet they should be made in such a way as to require the use of a minimum amount of capital on the part of the contractor, and at the same time enable him to pay his labor promptly, and to discount his bills for materials. If the contractor is expected to carry the work along on his own capital and credit, he is entitled to extra compensation, of course. The usual method of arranging the compensation calls for a settlement at the end of each month, in which 90 per cent. of the value of the labor and material in place on the building at that time is paid for. The remaining 10 per cent. is retained until the completion of the job and its acceptance by the owner.

Since the completeness and clearness, and therefore the usefulness, of a specification depend in a large measure on its systematic arrangement, the following outline or skeleton will be found of great value in preparing the finished instructions. This list is not offered as a complete form for all buildings, but as a reminder or guide.

Specifications are usually typewritten, several carbon copies being made at the same time, one set for the owner, and other sets for the contractor and sub-contractors.

SPECIFICATIONS

For a Country Residence to be Erected for

John Doe

At Doeville, Wayne County, Indiana.

GENERAL CONDITIONS

Materials and labor.
Delivery of materials.
Laying out the work.
Building laws and permits.
Protection of work.
Rubbish.
Scaffolding.
Defects.
Changes.
Sub-contractors.
Drawings and specifications.
Detail drawings.
Bond and insurance.
Ownership of old material.
Water supply.
Contingent work.
Terms of payment.
Time for completion.

MASONRY

Alterations and Additions:
  New underpinning.
  Piers.
  Shoring.
  Raising.

Demolition and Removal:

- Tearing down.
- Removing walls.
- Removal of old material.
- Old vaults and cisterns.

Excavation and Grading:

- Clearing the site.
- Excavate for cellar.
- Excavate for drains, etc.
- Finished grading.
- Wells and cesspools.
- Depth of footings.
- Shoring and bracing.
- Blasting.
- Surplus earth, loam.
- Removing trees and shrubs.

Stone Masonry:

- Cement, lime, and sand.
- Mortar and ties.
- Bed of stone.
- Bond of stone.
- Steps and walks.
- Coping and curbing.
- Facing walls.
- Damp-proofing.

Cut Stone:

- Limestone, sandstone, granite.
- Carving, cleaning, finish.

Concrete Construction:

- Cement, sand, aggregate.
- Mixing and handling.
- Footings, walls, floors.
- Reinforcement and centering, forms.

Brickwork:

- Lime, cement, sand.
- Common brick, pressed, and enameled brick.
- Bond—common, English, and Flemish.
- Wetting brick.
- Chimneys, flue linings.
- Hollow walls and chases.
- Chimney caps, flashings.
- Fireplaces.
- Freezing weather.
- Cutting and patching.

Terra-cotta—Hollow Tile:

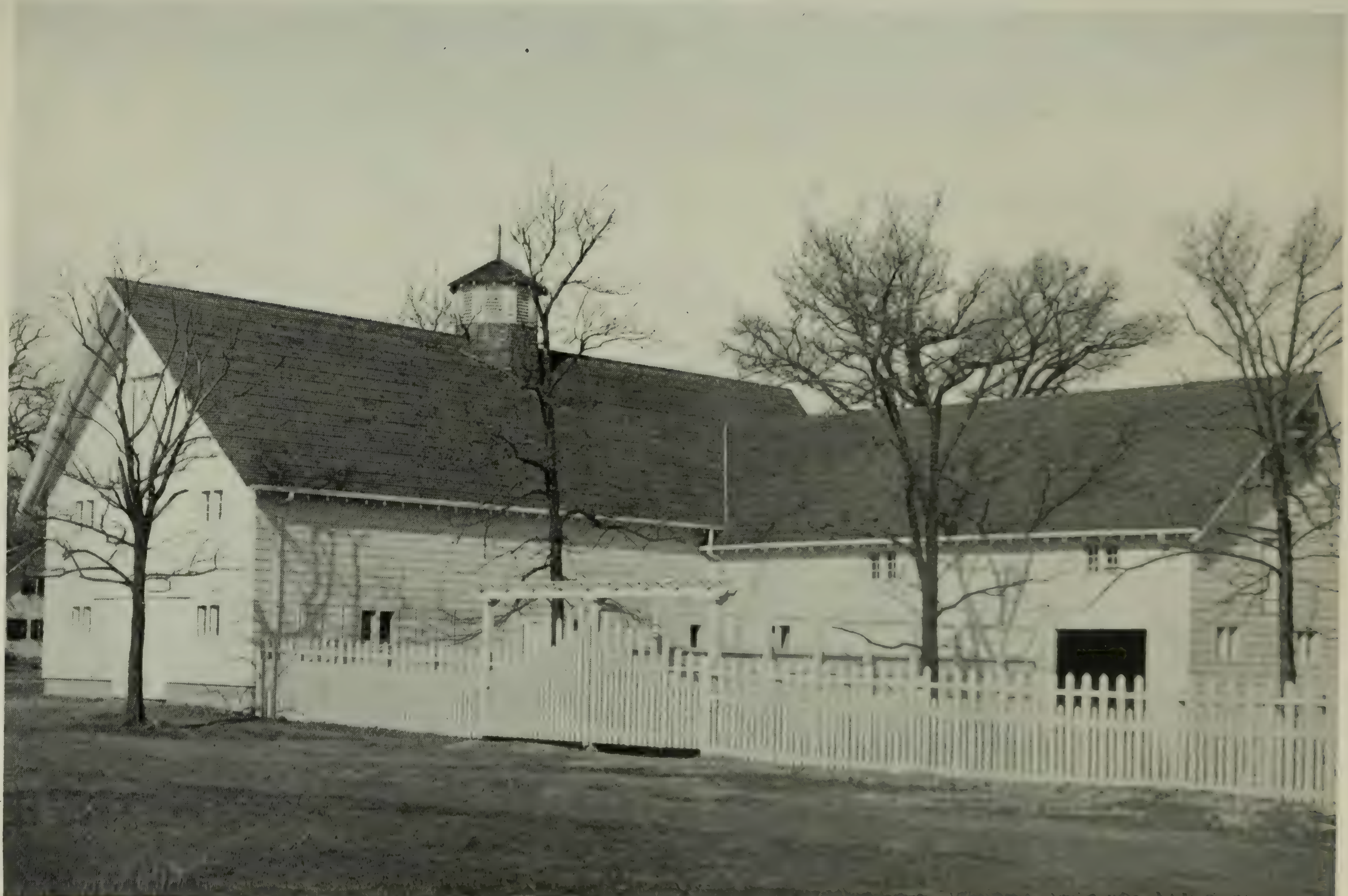
- Ornamental terra-cotta.
- Partitions, walls, floors.
- Fireproofing, furring.
- Mortar, reinforcement.

Plastering:

- Wood lath, metal lath.
- Exterior plaster, stucco.
- Grounds, back plastering.
- Two-coat, three-coat work.
- Corner beads and cornices.
- Lime, cement, mortar.
- Patent plaster, hair.
- Pebble dash.

Tile Work—Marble—Slate:

- Fireplaces, walls, floors.
- Mosaic, terrazzo.
- Plumbing marble.
- Bathroom.



Old farm buildings remodeled along modern principles

METAL WORK

Structural Steel and Iron:
Quality, tests, erection.
Bolts, rivets, painting.

Ornamental Iron and Bronze:
Steps and grilles.
Man-hole covers.
Vault lights.
Elevator enclosures.
Fire escapes, balconies.
Stable fittings, machinery guards.

Sheet-metal Work:
Ventilation flues.
Heating ducts.
Eave troughs, gutters.
Ventilators.
Copper, lead, zinc.
Speaking-tubes.
Cornice work.
Skylights.

ROOFING

Patent roofing, shingles.
Tar and gravel.
Tin, copper, galvanized iron.
Tile, slate, wooden shingles.
Pitch, valleys, flashings.
Snow guards.
Painting.
Expansion joints.

CARPENTRY

Sills, framing, flooring.
Sheathing, lining, paper.
Doors, sash, blinds.
Window weights, cords.
Interior finish, pine or hardwood.
Exterior finish, cornice.
Closets, refrigerators, mantels.
Stairs.

HARDWARE

Locks, knobs, hooks.
Sash locks, lifts, springs.
Nails, screws.
Special hardware.
House number, knocker.
Hinges, blind fixtures.

PAINTING AND GLAZING

General scheme, colors.
Quality lead, zinc.
Glass, single, double, and plate.
Number of coats, finish.
Putty, whitewash.
Stained, ribbed, wire.
Methods.

HEATING

Furnace, boiler.
Flues and ducts.
Covering, boiler and pipes.
Piping and hangers.
Radiators, registers, valves.
Guarantee, fuel consumption.

PLUMBING

- Fixtures, tubs, lavatories, sinks, etc.
- Connections, traps, branches.
- Hot-water boiler.
- Water piping, soil pipes.
- Leader pipes.
- Fresh air inlet, vents.
- Refrigerator drain.

LIGHTING

GAS FITTING:

- Gas machine.
- Pipes, tests, outlets.
- Stove, logs, heater.
- Lighting fixtures.

ELECTRICAL WORK:

- Description of scheme.
- Wiring, conduits, outlets.
- Meter connections.
- Lighting fixtures.
- Switchboard, switches, circuits.
- Vacuum cleaner.

To further illustrate the manner in which requirements are set forth in a well-written specification the following descriptions may be considered as characteristic:

TIME OF COMPLETION. Work is to commence immediately following signing of the contract and approval of building inspectors, and is to proceed with promptness and despatch. Completion of work and delivery of building to Owner to be one hundred working days after date of contract and approval of plans. The time allowed for ....

STONE MASONRY. Furnish all materials and build walls and footings as shown on drawings, or otherwise called for, of good local stone, in irregular courses, same to be laid to a line on outside face, well bonded, the joints to be thoroughly filled with mortar, and all to be pointed inside and outside. Mortar to be ....

CARPENTRY. Framing. The building is to be fully framed, braced, spiked, and pinned in the strongest, workmanlike manner, true and plumb. Framing timbers, except where otherwise specified, to be of ....

FORM OF AGREEMENT OR CONTRACT

In awarding the contract it is customary to enter into an agreement for carrying out the work, and an instrument is drawn for the signature of both the owner and the contractor. It is understood, of course, that the specifications and drawings form the principal part of the contract, and that the agreement is nothing more than a continuation of the specifications, covering in short, clear terms those items which are not included in the specifications, such as the sum of money involved. To have any legal standing the agreement must have a specific basis, and the specifications constitute that basis.

For ordinary purposes the following form will do very nicely:

AN AGREEMENT entered into this .... day of ...., by and between ...., of ...., Owner, party of the first part, and ...., of ...., Contractor and Builder, party of the second part:

WITNESSETH: That the said party of the second part, for and on consideration of the sum of .... dollars, in payments as set forth in the specification, agrees to construct a .... for the said party of the first part, at ...., in accordance with drawings numbered .... and specifications all prepared therefor by ...., which drawings and specifications are a part of and the basis of this agreement.

In consideration of the foregoing, the said party of the first part agrees to pay to the said party of the second part the full sum of .... dollars, in payments and under conditions as fully set forth in the specification.

In witness of the foregoing, the parties aforesaid here set their hands and seals to this and one other instrument of like tenor and date, this .... day of ....

In presence of: ....Owner (Seal)
....Builder (Seal)

Very often, as the work proceeds, changes will be necessary which involve either an increase or an allowance, and to avoid any misunderstanding a supplementary agreement or memorandum should be prepared for the signature of both parties.

As the work progresses and payments are made, the owner should be careful to obtain receipts from the contractor for the sums paid and for the work on which they apply. Sometimes these affairs seem very trivial, but if they are allowed to go unnoticed or without record, they may later form the cause of a disagreement and unpleasant dispute.

NEED FOR PLANS OR SKETCHES

We have gone pretty generally into the matter of the specifications, and now for the subject of drawings. It is difficult, almost impossible, to establish the basis for a contract without plans of some kind, if only rough pencil sketches. Plans are intended to show *what is to be done*, whereas the specifications describe *how it is to be done.* Wherever possible, drawings should be made to scale, having all the principal dimensions clearly marked on them. If this is impracticable, and the proposed structure is not too extraordinary or too involved, a rough pencil outline can be substituted, illustrating as fully as possible the general shape, contour, and architectural treatment of the building. Make a plan of the excavation, showing the depths and grades, walls, footings, piers and abutments, their material and thickness, and the general arrangement of the cellar and the purposes for which it is intended. Work out a similar plan for the first floor and for any

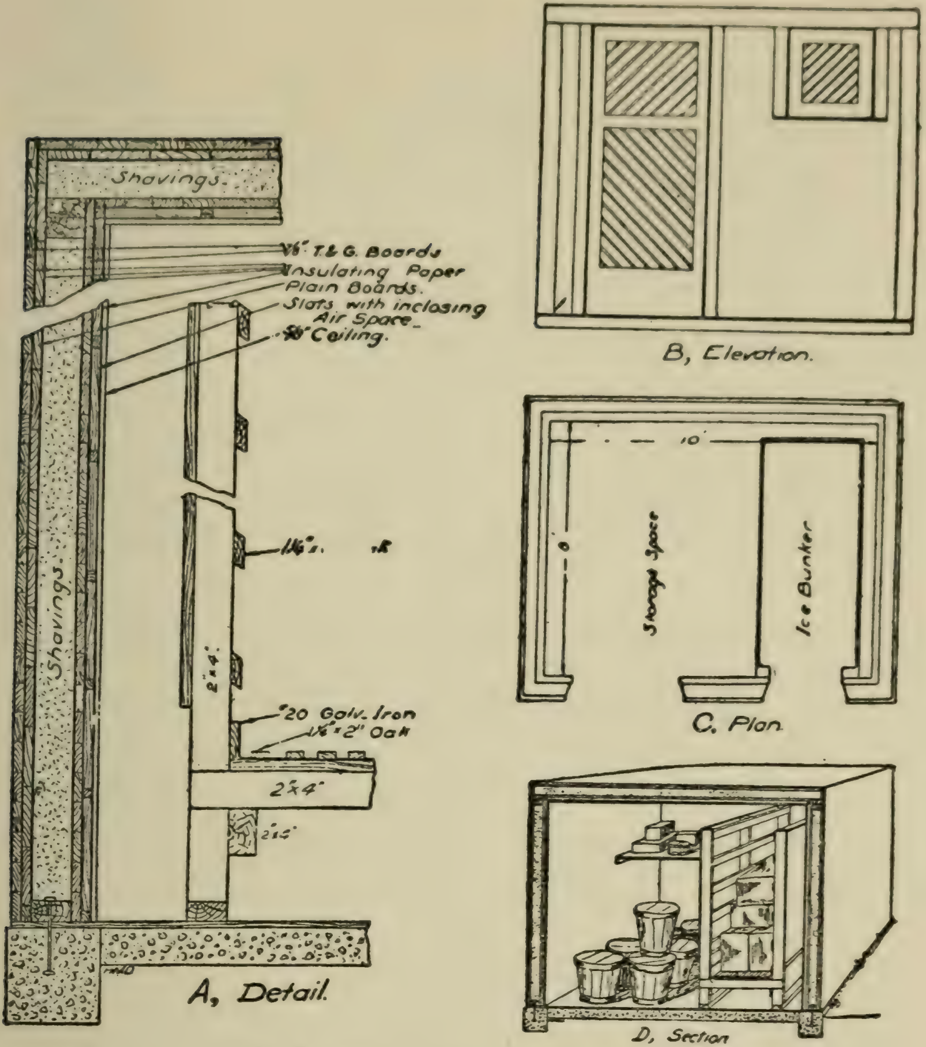


Fig. 8.—Plan of a farm refrigerator.

other floors, or for a mow space, as in the case of a stock barn.

To illustrate the exterior of the structure sketch a view or elevation of each side, noting the position of the doors, windows, and other openings, the height of the foundation wall above grade, and any other projections or levels; also give the shape of the roof, whether gable, hip, hip and valley, or gambrel, and mark the position of cupolas, towers, or ventilators. For the interior draw a typical cross-section to indicate the framing, floor supports, roof supports, if any, stairs, light wells, ventilating ducts, and other openings.

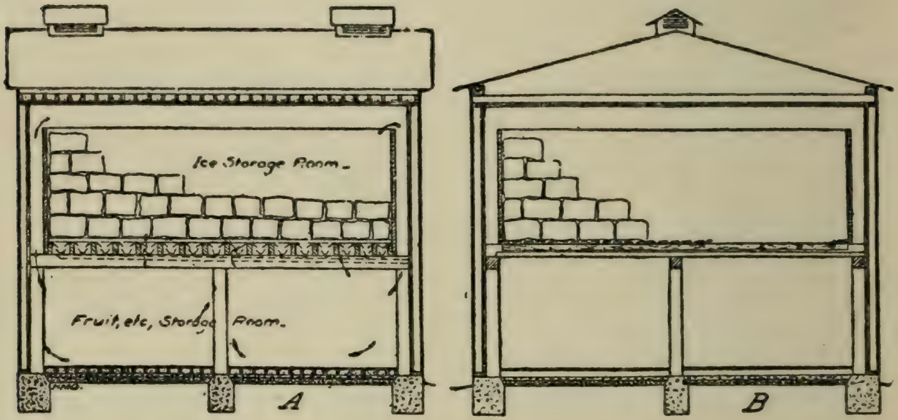


Fig. 9.—Ice-house planned for storing ice above and fruit below. *A*, Longitudinal section; *B*, transverse section.

In preparing the plans for a dairy barn surround yourself with catalogues on modern barn equipment, and with bulletins from Experiment Stations and other sources; if contemplating a dwelling, look up designs in books and magazines, write for a variety of catalogues on building materials; there is a mine of information to be had from these sources, and most of it is prepared by experts—and offered gratis. Consider well the advantages of each style of construction and every kind of material; better still, consult a reliable contractor or two and get their views on the subject. They may suggest the very thing you want. Above all else, satisfy yourself that a particular design or method of construction is the one best suited to your purpose.

Having made a rough sketch and gone into the preliminary work in a general sort of way, you will want some idea of the cost of the structure before preparing the final specifications and advertising for bids. Or, in handling the job yourself, it is natural for you to want a fair estimate of what the work is going to cost. Only a few can proceed with an improvement without first considering its cost.

RATES FOR APPROXIMATING COSTS

Estimates are formed by varying methods. The only reliable way is to take off the actual quantities in detail and carry out the prices for labor and material, adding certain rates for overhead expenses, profit, and so on. For this, however, accurate and complete drawings and specifications are necessary. To obtain an approximate cost of some proposed work engineers and architects have compiled sufficient data from which it is possible to draw certain averages, such as the cost per cubic foot, or the cost per square of a hundred square feet, or the cost per unit, such as the cost per room in tenements, or the cost per cow in a first-class stable, or the cost per scholar in a public school.

The cubing system, or the cost per cubic foot, is perhaps the most dependable method to use on structures

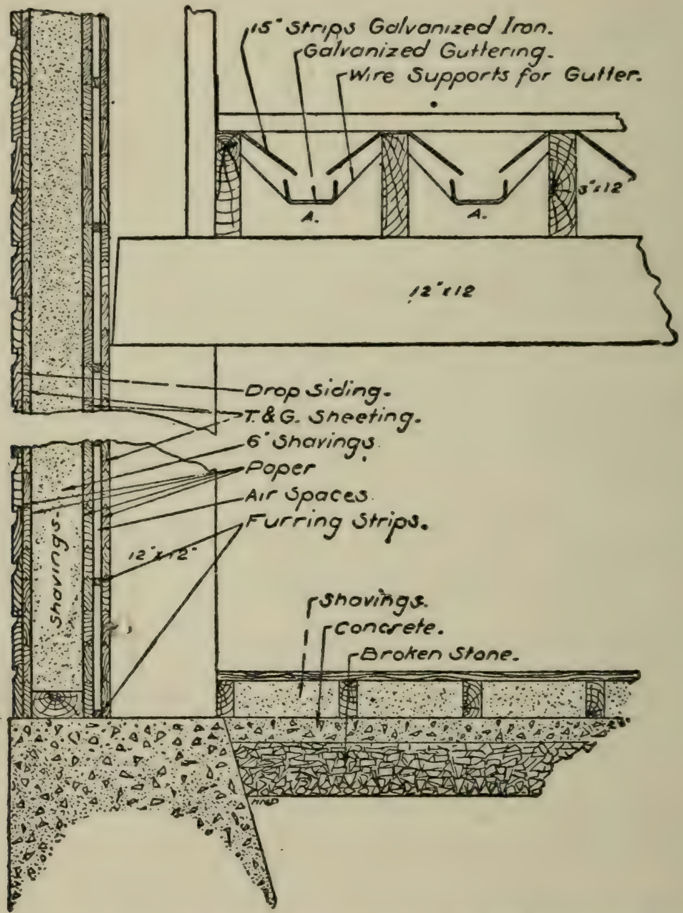


Fig. 10.—Diagram showing wall construction of ice-house as illustrated in Fig. 9.

of more than one story, as, for example, a dwelling house. The dimensions are taken from the length and breadth of the building, the outside measurements, and the height as representing the distance from half-way to the foundation footings to half-way up the roof. The product thus obtained is then multiplied by the price per cubic foot on similar buildings.

The following is a list of rates compiled from the best authorities and from practical experience:

	Per Cubic Foot.
Bungalows and small cottages, frame	$0.15 to $0.20
Bungalows and small cottages, brick, tile, concrete, stone	.20 to .24
Stables, wood, for cows	.12 to .16
Stables, brick, tile, concrete	.16 to .20
Barns, frame throughout	.05 to .07
Barns, partly concrete, tile, stone	.07 to .10
Sheds, rough, frame throughout	.04 to .06
Libraries, large residential work, cut stone, hardwood finish	.30 to .35

Estimating by the square is considered by some authorities to be more convenient than cubing, also that it gives a better idea of the real conditions. This may be true when applied to cheaper, one-story structures; there are arguments in favor of each system, but, as previously mentioned, both methods are approximate only, and depend upon the estimator's judgment rather than his accuracy.

The customary method of estimating by the square is to take off the area of the shell of the building, first the walls, then the floors, the partitions, the roof, and any interior finish. Figures are then compiled for each class of squares, depending upon their construction, thickness, and manner of finishing. These prices are then applied to amounts contained in each class and the whole added together. The wall squares must include all excavating, masonry, framing, plastering, painting, and paperhanging; the floors must comprise joists, bridging, lathing of ceilings and plastering same, and any ornamental work; and the roof shall consist of the framing, sheathing, flashings, eaves troughs, cornice, and the roofing material itself, such as shingles, tin, slate, tar and gravel, and so on.

It is not advisable to employ an approximate estimate as the basis of a contract unless the estimator has had continued experience in a particular line of work, and feels tolerably certain of his judgment. Even then it is a good plan to add a fair percentage for any contingencies. In the next chapter we will discuss ways of making up an accurate estimate, how to take off quantities, and how to compute prices on labor and materials.

CHAPTER II

FIGURING THE MATERIALS REQUIRED AND THEIR COST

WHETHER you do your own building or put out the work at contract, you will soon find that it is to your advantage to know how to estimate the cost of a job. The ability to make up a reliable estimate is the crux of the building business. It is the dividing line between the ordinary mechanic and the master builder.

John Keene, an old-time ship carpenter, the man who taught me more about the use of tools and the principles of carpentry than any one else, was as good a mechanic as ever handled a broad ax. We used to say John was keen in everything, including his name and his wit, with the exception of figures. He could use his rule, you understand, with the greatest precision, and he seldom made an error in laying out his work. He was quick, a clear thinker, steady, skilful, and thoroughly workmanlike. He could turn out a spar, cut a stern-post, lay a keel, or execute a piece of cabinet work with the same ease that you and I could saw off a stud, yet he had no ability in figuring the materials required for a job.

John had always worked for someone who did the figuring for him. When he wanted a certain size stick of timber or hardware of any kind he walked to the lumber pile or storehouse and selected it. If what he wanted was not in stock he notified the boss. The boss ordered it. In consequence, John always worked for someone else. One time he was offered a contract to put up a wharf. He took the job, but it cost him a large portion of his savings to finish it. He "guessed" wrong on the timber required.

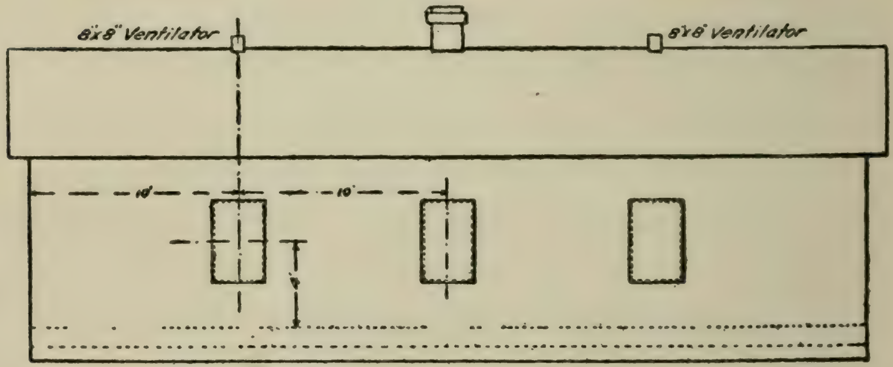


Fig. 11.—Side elevation of a sweet potato storage house.

Don't take this story to mean that in learning how to figure quantities and costs you have a tremendously difficult undertaking before you. The thought of estimating the cost of a structure may impress you as a dull, methodical task, which is true in a sense, because it is necessary to wade through a maze of figures and prices, yet it is not without considerable interest, and the experience gained will be of great value in preparing future estimates. And you can add greatly to the interest if records are kept of the actual cost of the work as it proceeds, which may be compared from time to time with the original estimated costs.

You can also disabuse your mind of the fact that a profound knowledge of mathematics is necessary. A familiarity with the elements of arithmetic, particularly the terms of mensuration, is all that is required for every-day work. If you run into engineering problems of any consequence, it is a simple matter to refer to a text-book or consult an engineer. For the present, at least, we need concern ourselves only with the ordinary problems.

ESTIMATING IS AN IMPORTANT FEATURE

I have said that the ability to estimate the materials required in a structure, together with their cost, including labor, is about as important as the ability to perform the work. Let me put the idea in another way: From the contractor's point of view estimating is the most important feature. On it depends his chances of securing the job, especially if the job is open to sharp competition. What is even more vital, his profit depends upon the accuracy and judgment of the estimator.

It may sound strange to you, but one of the most successful contractors of my acquaintance is a man who never actually worked with tools. I am not exaggerating when I say that this man is so unskilled in the use of tools himself that he cannot drive a nail without bending it or his thumb. He's a fine fellow; I've known him for years; and I know from my own observation that if there is a picture to be hung at home his wife drives the nail. Yet this man is a wizard at estimating. That is how he got into the contracting business. During the summer months, while working his way through a technical school, he took odd jobs as estimator with a builder. He soon became proficient, and his figures won a great deal of work for his employer. The business grew rapidly, and in a few years this estimator bought a controlling interest in the establishment, and made his former employer—the practical man—general

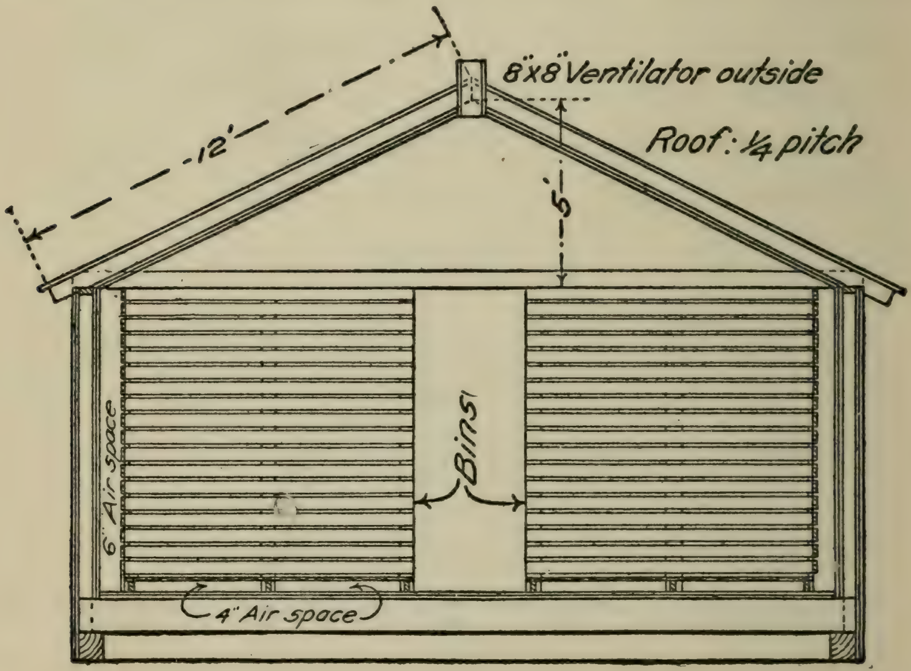


Fig. 12.—Cross-section of sweet potato storage house, as shown in Fig. 11.

superintendent. Under him are thoroughly competent, practical foremen for all branches of the work.

I mention this, merely to illustrate the importance of estimating. It is better, of course, to be an all-round mechanic as well as an estimator. The farmer, who is but an occasional builder, cannot be expected to make up a schedule of material and labor that will be complete in every detail, yet in discussing the subject we will consider it from the contractor's standpoint. It is certain to be of benefit to you, whether you do your own work or employ the services of a builder.

As might be expected, there are varying methods of figuring the cost of a structure or operation. But there is only one accurate, dependable way, that of taking off the actual quantities of the different materials and carrying out the prices for each item, both as to the cost of the materials delivered at the building site and the amount of labor necessary to erect them in their permanent position. These are added together and the sum used as a basis on which to figure such percentages as profits, office expenses, and general overhead charges. "Overhead" is of small importance in your case, because you have no office rental or clerical force; you are not making a business of contracting, consequently there are no fixed charges.

Estimating by "cubing," "squaring," by the unit basis, or any other method is approximate only. Make a strong mental note of that point. Such methods serve a very valuable purpose. They are used to convey a general idea of the cost of some proposed work, usually prior to the development of working plans and specifications, but they should not form the basis of a contract. "Cubing" is another term for jumping at the cost of a building operation; and since to leap in the dark may land you in considerable trouble, it is best to avoid it.

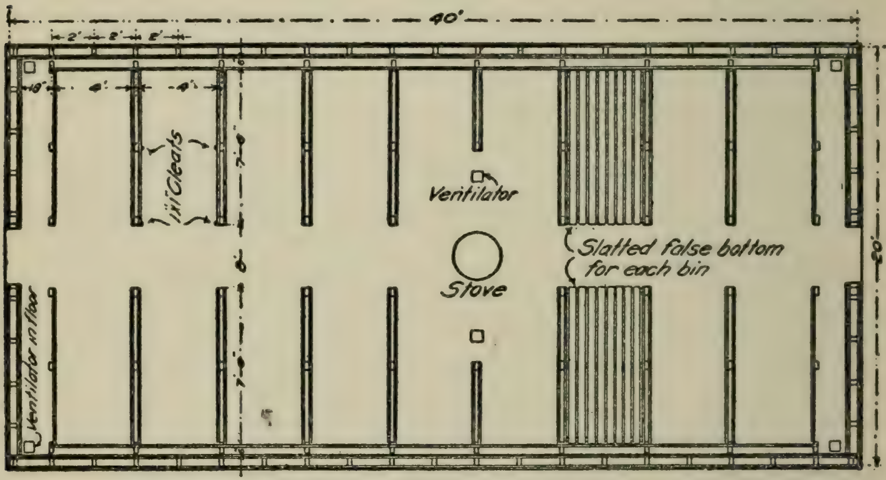


Fig. 13.—Ground plan of sweet potato storage house, as shown in Fig. 11.

Much of the accuracy of an estimate depends upon a systematic mode of conducting the work. By that I mean that you should commence with the excavation, or work preliminary to the excavation, and follow out each branch of the operation in proper sequence, as it would be performed in practice. In so doing you are less likely to forget something. Don't figure out the concrete in the foundation walls, and then jump to the rain water conductors, and then back to the interior finish. Concrete comes under the heading of masonry; when you start to take off the masonry see to it that you have covered every part—the stonework, brickwork, hollow tile, chimneys, water-proofing, cement flooring, drains, cesspools, steps, curbing, and coping.

WORK PRELIMINARY TO EXCAVATION

In erecting a structure of any kind the work commences at the earth. Following the same rule, the first items to be estimated are the excavations for cellar, foundation walls, footings, drainage trenches, and so on. Sometimes there is work preliminary to the excavation. Be careful to give this point due consideration. You should make a survey of the site, and note the nature of the soil, contour of the ground, and if any preparation is necessary before starting the actual digging. Perhaps there is some rubbish to clear away, an old building to demolish, trees to cut down, and others to be protected by "boxing." Figure the distance from the railroad or wharf, whence the materials will have to be hauled. Form some opinion as to the condition of the roads and their grade, especially if the work is to be done in the winter time. These factors will influence the extent of the hauling. Bad roads will effect the size of the loads, and may double the cost of this item.

On a building of any size the cost of hauling is quite considerable. I have been associated with jobs where it amounted to over a thousand dollars. Unless you can handle it with your own teams, you had better obtain prices from some local teamster or from neighboring farmers. Wherever possible get a price per ton; it is

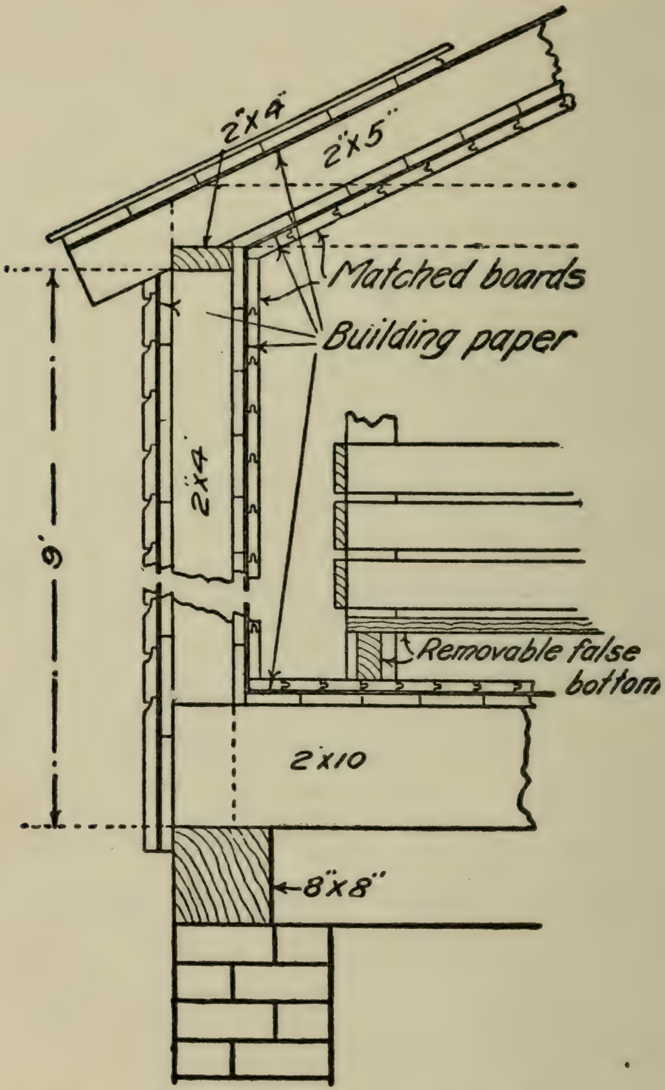


Fig. 14.—Detail of construction of sweet potato storage house, as shown in Fig. 11.

the most satisfactory way to pay for hauling; disputes are not so likely to arise, as in the case of day-work, and it is an easy matter to check up the bills.

POSSIBLE UNDERGROUND DIFFICULTIES

Remember, also, in this preliminary work there may be underground difficulties to take care of, such as rock blasting, springs, shoring, and piling, the extent of which can only be approximated. A fair knowledge of the sub-soil can be obtained by a few borings with an earth auger, such as is used for digging post holes, or by digging test pits here and there on the site. If you have any serious misgivings as to what lies below the surface, unquestionably it will pay you to take some precaution.

An unforeseen ledge of rock or strata of water are likely to prove costly. By changing the site a few feet in another direction this expense may be avoided. On the other hand, you may find a deposit of sand or gravel which will not only save carting away as excavated material, but, if it is of the proper quality, it may be used for masonry work.

Items of this character are constantly occurring in the contracting business, so that it pays to first gain reliable knowledge of existing conditions.

SIMPLE RULES OF MENSURATION

Let us assume that we are now ready to take off our quantities. As I mentioned in an earlier remark, in order to figure from a set of plans or from a sketch it is essential to have a fair knowledge of arithmetic. Perhaps you have forgotten some of the rules for finding the areas and volumes of different figures. Rules are the most elusive things in the world to me if I'm not constantly using them. Here are a few of the more important ones:

The area or superficial dimension of any figure is the measure of its surface without regard to its thickness. For example, the area of a rectangle 4 feet long and 2 feet wide is found by multiplying the length by the width, or 8 square feet.

Other rules apply to figures containing an irregular number of sides and varying angles, and for these it is best to refer to some text-book. They are too numerous for consideration here. Besides, most of them are used so occasionally it is questionable if it pays to bear them in mind.

CUBICAL CONTENTS

The cubical contents of any figure is the measure of its solidity, and has reference to three dimensions—length, breadth, and thickness. This capacity is usually expressed in cubic feet or cubic yards. Let us take, for example, a section of a stone wall 4 feet long, 2 feet wide, and 4 feet high; the cubical contents is found by multiplying the length by the width and then by the height, or 32 cubic feet.

The linear dimension of a figure expresses its length in a direct line, and has no regard to breadth or thickness. Thus, linear measure, square measure, or area, and cubic measure, or volume, may be said to form the real basis of estimating.

EXCAVATION—DIGGING

For convenience, excavating is priced by the cubic yard, there being 27 cubic feet to the yard, which is about equal to a single load, or a trifle more than a ton. We proceed to figure the cubical contents of a cellar or other excavation the same as we find the contents of a box; multiply the length by the width and then by the height. If the shape of the excavation is irregular, it will be necessary to plot it out in a rectangular manner, like a series of boxes. (See Fig. 15.)

More than likely there will be a variation in the depth of the excavation, either caused by different levels or by the slope of the ground. In that case the only accurate method is to plot the work into a number of squares and figure each square separately. For ordinary purposes, however, you will be able to make a pretty good guess at the average depth.

You will understand that the cost of excavating varies widely in different localities and under different conditions, therefore it is out of the question to establish anything like fixed rates. Everything depends

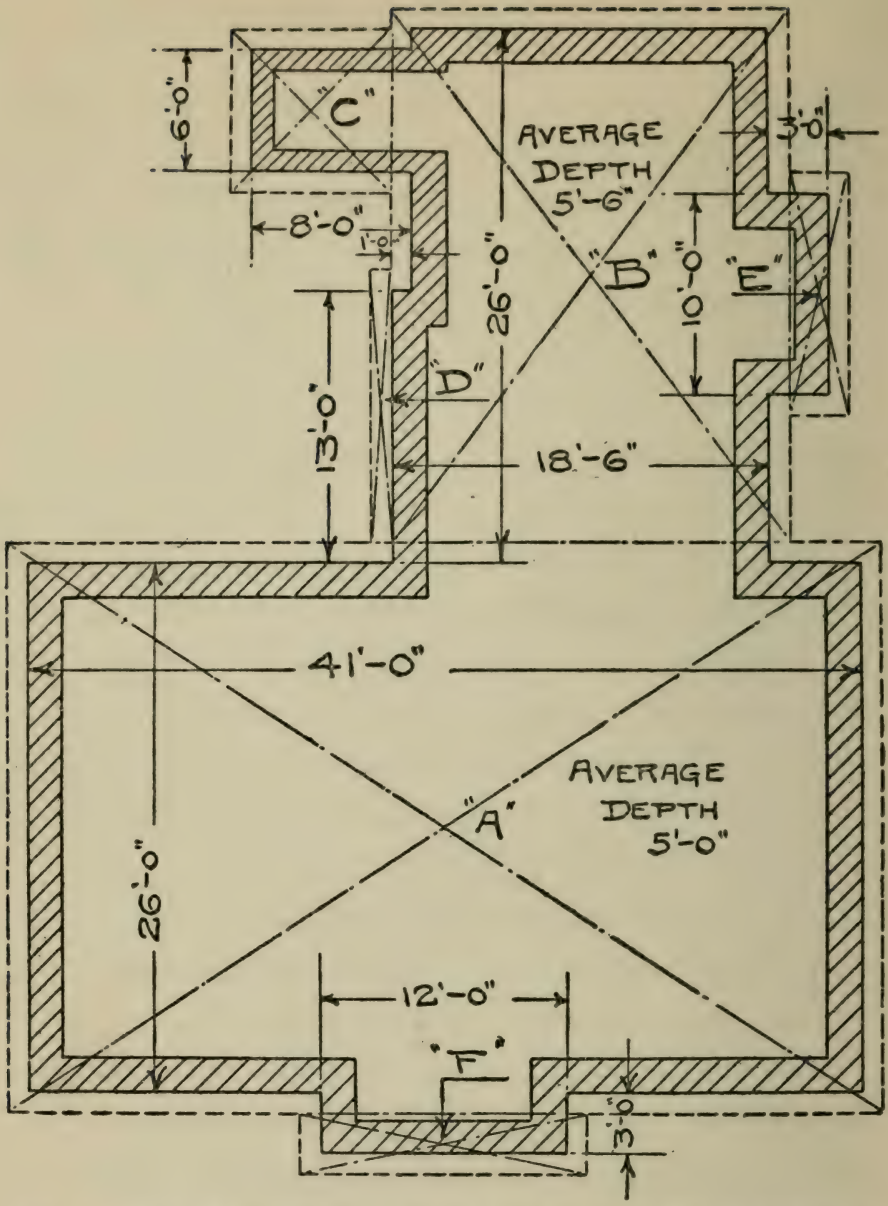


Fig. 15.—Plan of excavation. Dotted line indicates line of excavation 12 inches outside of all walls.

Plot "A" = 43′ x 28′ x 5′, or...... 6020.0 cu. ft.
Plot "B" = 19′ 6″ x 26′ x 5′ 6″, or 2788.5 "
Plot "C" = 8′ x 8′ x 5′ 6″, or..... 352.0 "
Plot "D" = 13′ x 1′ x 5′ 6″, or.... 71.5 "
Plot "E" = 12′ x 3′ x 5′ 6″, or.... 198.0 "
Plot "F" = 14′ x 3′ x 5′, or....... 210.0 "
Total........... 9640.0 cu. ft., or 357 cu. yds.

upon the character of the soil, the nature of the work, and the facilities for performing the work. The following suggestions will enable you to get a pretty good line on this subject:

A competent, reliable laborer will dig and throw into a cart or barrow in a day of ten hours from 8 to 10 cubic yards of ordinary soil, providing it is not necessary to use a pick. In stiff clay or firm gravel, and without picking, the same laborer will remove from 5 to 6 cubic yards in a day. In hard ground, where constant picking is required, he will excavate from 3 to 5 yards.

Soil excavated to a depth of 6 feet can be tossed out of a hole or trench in one throw. Greater depths will require additional "throws," or else the material must be carted or removed in wheelbarrows. By "additional throws" I mean that the soil is thrown on to shoveling stages or platforms, from which it is re-thrown clear of the excavation. You have probably seen this done in deep excavations in the city, where, perhaps, there was insufficient room to erect a runway for teams or space to install a lift.

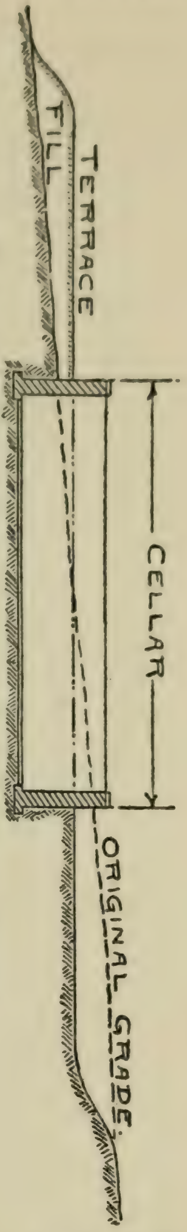


Fig. 16.—Building on a slope provides use for excavated material.

It is well to figure the excavation of trenches separate from the larger areas, as the cost of digging a trench, especially if it exceeds 4 feet in depth, will be greater, owing to cramped working quarters.

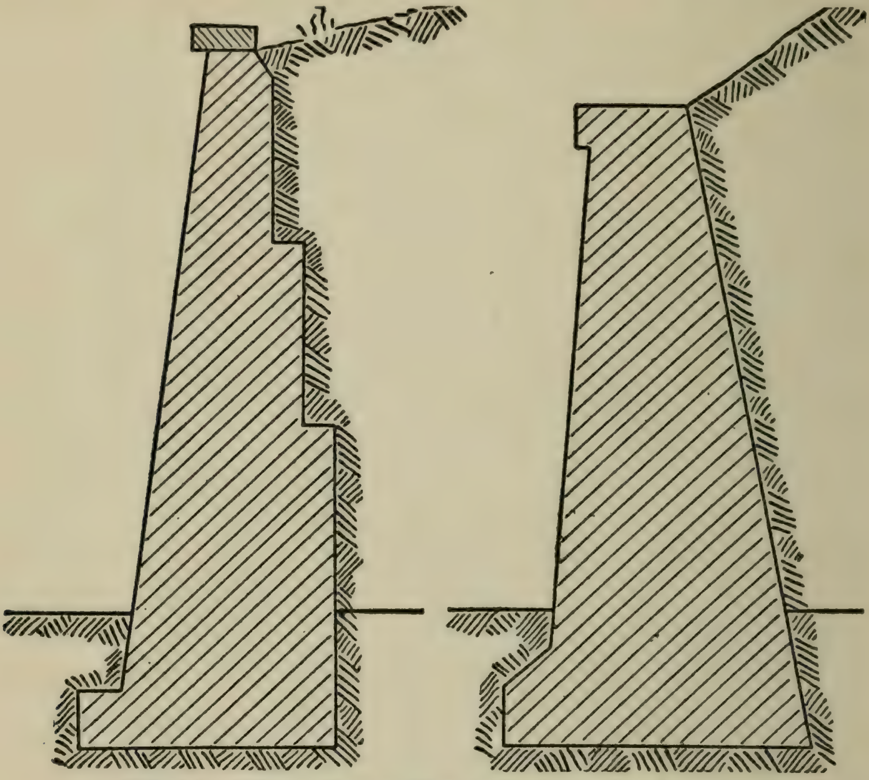


Fig. 17.—Types of retaining walls for embankments.

COST OF EXCAVATING PER CUBIC YARD

Earth that is loose enough to be shoveled without the use of a pick, and which can be thrown clear of the excavation by a single operation, may be removed for about 16 cents per yard. Sounds cheap, you will say. Think a moment. That price is based on a wage of 20 cents an hour. A good laborer will dig a yard in forty-five minutes, and still have time to mop his brow, light a pipe, hitch up his trousers at regular intervals, and pause for a drink.

With the aid of a plow and horse scraper, and by digging and simply dumping the earth a short haul from the excavation, the work can be done for about 12 cents per yard. If the material is loaded into carts it will cost about 30 cents per yard. Very heavy clay or hard soil will cost from 50 cents to $1.00 a yard to remove. Rock will cost from $1.50 to $10.00 per yard, or more, depending upon the character of the rock, facilities for blasting, and so on.

Refilling and ramming around walls after the job is completed, another term for which is "back-filling," will run about one-third the cost of excavating the same amount of material, with the exception of rock.

It is poor policy to try and save on the cost of excavating by keeping too close to the foundation lines. A certain amount of erosion is to be expected, particularly in friable soils, and this caving-in or sliding will only hinder the progress of the masons if the bank is not kept far enough back. Furthermore, the masons require room to porridge or plaster the outside surface of the masonry, especially if the walls are to be damp-proofed. Better allow a foot outside of all walls and footings; this will only amount to a few extra yards, and pays in the long run.

The depth to which the excavation can be carried without shoring, the distance to which the excavated material is to be carted, and whether the top soil is to be kept separate from the subsoil for subsequent grading, are other problems to be taken under consideration at the time the excavation is figured. Another point to remember in connection with the removal of excavated material: its bulk will increase about one-third when dug and thrown into a loose heap.

Make a note of this list of the capacities of the most common appliances used in excavating and hauling. It is subject to variations, of course, but it will aid you in making up an estimate:

Ordinary builder's cart will hold about 27 cu. ft. or 1 cu. yd., which is equal to about 2400 lbs. common earth.

Double load equals about 56 cu. ft. or 2½ tons.

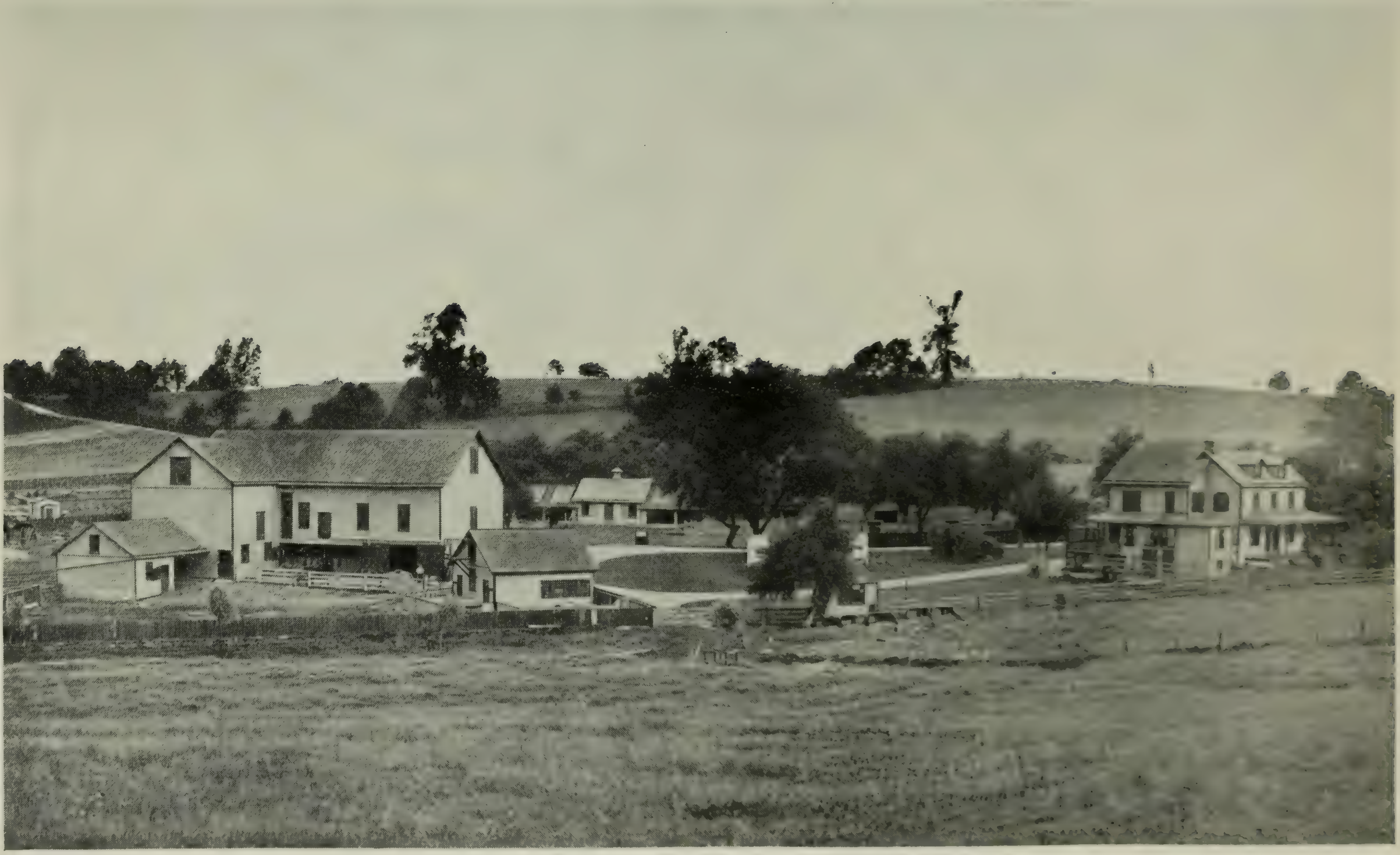
Large wheelbarrow will hold when heaped $\frac{1}{10}$ cu. yd.

500 bricks make a single load, or 16 bushels of lime, or 1000 plain roofing tiles, or 1000 slates, counters.

1000 board feet dressed lumber is considered a single load, or 50 cu. ft. of timber.

KINDS OF MASONRY

Continuing the policy of taking up the various structural items in sequence, as they would appear in practice, the next subject is that of walls and foundations—the masonry.



Farm buildings grouped for convenience, appearance and service

We are accustomed to think of masonry as meaning stonework exclusively, but the true meaning of the term is more general. Masonry construction is classified according to the nature of the materials used, such as "stone masonry," "brick masonry," and "concrete masonry." Then again, "stone masonry" is classified in two ways, first, according to the manner in which the material is prepared, and second, according to the manner in which the work is executed.

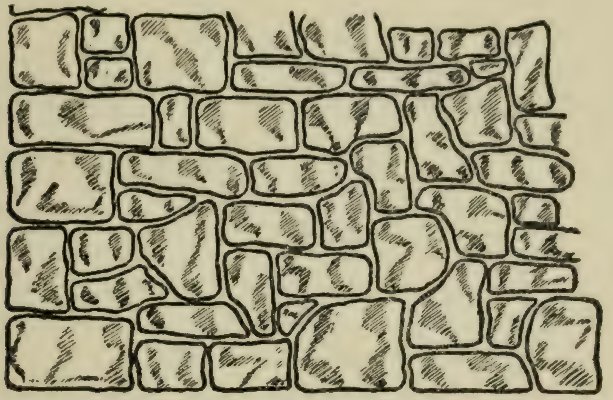


Fig. 18.—Rubble masonry: Irregular stones without any attempt at courses.

Masonry composed of unsquared stones is called "rubble," which, in turn, comprises two classes: (1) "Uncoursed rubble," in which stones of different shapes and sizes are laid without any attempt at regular courses, and (2) "coursed rubble," in which the stones are leveled off at specific intervals to an approximate line. (See Fig. 19.)

Ashlar masonry is composed of blocks of stone cut to regular figures, generally rectangular, and built in courses of uniform height. The distinction between "regular ashlar" and "broken ashlar" and other classes of cut stonework will be described later. For the present we will consider them in a general way.

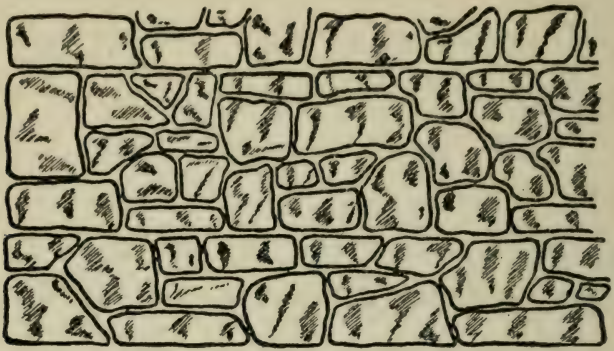


Fig. 19.—Coursed rubble: Unsquared stones leveled at regular intervals.

MEASURING STONEWORK

Stone masonry is measured by two systems: Quarryman's and Mason's Measurements. In the former the actual contents of the work is measured. In the latter no allowance is made for openings less than 3 x 3 feet, all piers and corners are doubled, and arches are counted solid from their spring. The spring of an arch is the point from which the curve of the arch starts from the supporting wall or abutment. The Mason's system is more commonly used; it is the easiest, and renders equally reliable results. In taking off a stone foundation by this method, it is customary to measure each wall from outside face to outside face, thus doubling the corners. This *doubling* is considered to make up for the extra care and labor of laying up the corner. For the same reason small openings are counted solid.

Stone walls are figured by the perch. A perch is 16½ feet long, 1½ feet wide, and 1 foot high, and contains 24¾ cubic feet. A perch in the wall contains about 22 cubic feet of stone and 3 cubic feet of mortar, hence in some localities the unit of 22 cubic feet is reckoned as a perch of masonry. For estimating purposes no wall is considered to be less than 18 inches thick. In fact, it is almost impossible to lay up a strong wall of undressed stone less than 20 inches thick. Water tables and base courses are usually measured by the lineal foot, and all sills and lintels or ashlar by the superficial foot.

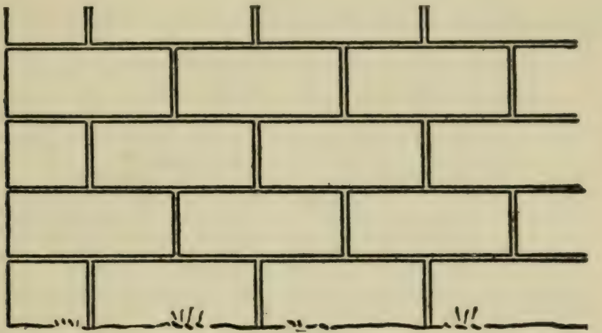


Fig. 20.—Regular ashlar masonry: Square stones laid in uniform courses.

A cord of stone, 3 bushels of lime, and a cubic yard of sand will lay 100 cubic feet of wall. The cost of laying a perch of "rubble masonry" in cement mortar will average about $3.50 for foundation work, and may be apportioned as follows:

1 perch stone		$1.00
½ bbl. cement	@ $1.30	.65
⅙ load sand	@ 1.75	.29
¼ day mason	@ 4.50	1.13
¼ day laborer	@ 1.60	.40
		$3.47

It is impossible for me to quote prices on cut stonework; they differ according to the kind of stone, the distance from the quarry, and in the amount of labor involved in the cutting. Then, too, prices fluctuate from time to time on the same grade of stone. Granite, limestone, sandstone, and bluestone are the principal kinds of stones used for building purposes. It is hardly likely stonework of this kind will be needed for farm buildings, with the possible exception of door and window sills or wall copings. For these you may allow a price of $1.50 per lineal foot, in the wall.

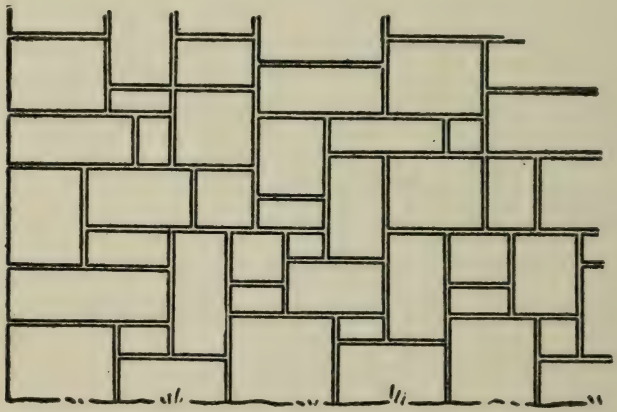


Fig. 21.—Broken ashlar masonry: Squared stones of unequal depths laid without any attempt at regular courses.

BRICKWORK

Brickwork is generally measured by the thousand bricks, and it is very easy to take off. First obtain the superficial measurement, the number of square feet, in the walls, keeping walls of different thicknesses separate and for every 4 inches of the thickness of the wall, which is the width of one brick, add 7 bricks per square foot. In other words, for a 4-inch wall, which really amounts to a single-brick veneer, multiply the number of square feet contained in the wall by 7; for an 8-inch wall, which is equivalent to 2 bricks in thickness, multiply the area by 14; for a 12-inch wall (3 bricks thick) multiply by 21; and for a 16-inch wall (4 bricks thick) multiply by 28.

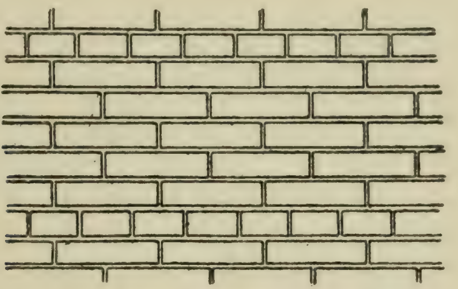


Fig. 22.—Common bond brickwork: Row of headers every sixth course.

In taking off the areas of brick walls, as in the case of stonework, it is customary not to deduct for small openings, for the reason that building around an opening is equivalent in labor to laying the wall up solid.

In determining the number of bricks a mason will lay in a day, a great deal depends upon the thickness of the wall and the character of the work. On a plain wall, 8 inches thick (in reality such a wall will be nearer 9 inches thick after allowing for the mortar joint), a good mechanic will lay from 1200 to 1400 bricks; on 12-inch work the same mechanic will lay from 1500 to 2000 bricks; and on 16-inch work the rate will be increased to 2200 bricks.

Single-brick veneering, or 4-inch work, is very much slower, owing to the niceness of the work, and because of the necessity for tying the bricks to the framework or sheathing. For such work 500 bricks is considered a good average for a day.

The cost of brickwork in the wall by the thousand may be analyzed something like this:

1000 bricks, common		$ 9.00
1¼ bbl. cement	@ $1.30	1.63
½ load sand	@ 1.75	.88
⅔ day mason	@ 6.00	4.00
⅔ day laborer	@ 1.60	1.06
		$16.57

Face bricks, which may be had in a variety of textures and colors, also enameled bricks, will cost from $25.00 to $50.00 per thousand, unlaid.

CHIMNEYS

Ordinary brick chimneys, for a 12 x 12 flue, may be erected for about $1.50 per running foot, which includes labor and material, and a flue lining. If the chimneys are at all complicated, it is better to figure the construction in detail, in the same manner as taking off a wall.

TERRA-COTTA HOLLOW TILE

Terra-cotta hollow tile is another form of masonry. As a building material it is increasing in popularity by leaps and bounds. The standard multiple or unit is 12 x 12 inches, and tiles may be obtained in almost any thickness up to 16 inches. For convenience they are also made in half tiles, 6 x 12 inches, in the different thicknesses. Thus, each tile or block in an 8-inch wall is equal in bulk to about 14 bricks, and when you consider that the tile is laid almost as simply as a single brick, it is easy to understand that it represents a big saving in mason's labor. In a 12-inch wall each tile is equal in size to 21 bricks, and in a 16-inch wall, 28 bricks.

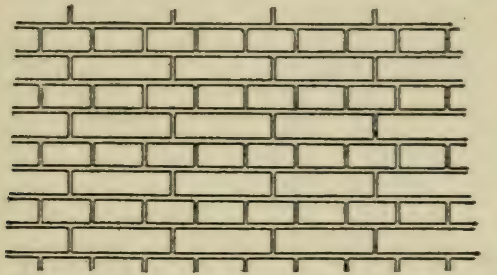


Fig. 23.—English bond brickwork: Alternate rows of headers and stretchers.

A few years ago terra-cotta hollow tile was used almost exclusively for fireproofing purposes. Today it is made in a variety of shapes for structural purposes as well. It is manufactured for partition walls, bearing walls, linings, arches, jambs, piers, floors, and so on. In fact, it is made in such a great number of ways, for so many special purposes, it is out of the question to quote prices on this material. Where you have need for any great quantity of it, you had better ask for quotations from the manufacturers or dealers. And be sure to specify the basis on which you want the prices quoted, whether on cars at the factory, at your freight station, or delivered to the building site. Tile is very much cheaper when ordered in car-load lots.

For comparative purposes you will be safe in figuring on a price of 16 cents per block for a 12 x 12 x 8-inch tile—the last figure being thickness—laid in the wall. Figure the number of tiles required in square feet, and keep each kind separate.

CONCRETE

There is still another form of masonry to be considered, probably the most generally used for all-round farm purposes—concrete. In all cases where the proportion of concrete is expressed in numerals, such as a 1-2-4 mix, or a 1-2½-5 mix, the first numerical term refers to cement, the second term to sand, and the third term to crushed stone, pebbles, cinders, or other large aggregate. Of only two numerals are expressed in cement work, such as a 1-3 mix, the first term refers to cement and the second term to sand.

To estimate the quantities of ingredients required for a concrete job, which is the only dependable way to get at the cost, the following simple method will be found easy to remember: First figure the capacity or contents of the forms, get the actual volume of concrete required, whether intended for a wall, pier, culvert, foundation, footing or floor, in cubic feet. Let this product represent the quantity of the large aggregate. In other words, the amount of crushed stone, pebbles, or cinders required is equal to the total cubical contents. Then, if the desired proportion or mixture for the concrete is 1-2-4, since 2 is one-half of 4, the necessary sand or small aggregate will be one-half of the large aggregate, or crushed stone. Similarly, the cement is one-fourth the amount of the large aggregate.

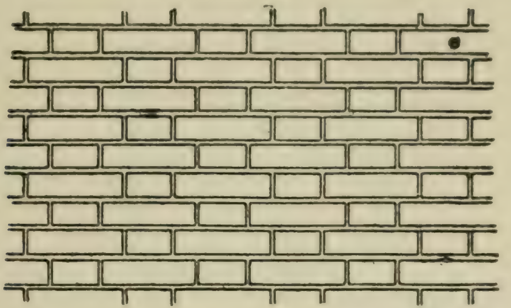


Fig. 24.—Flemish bond brickwork: Alternate headers and stretchers in every row.

You might raise the question: What becomes of the sand and cement, if the volume of crushed stone is equal to the total contents of the forms? Simply this, the sand and cement go to fill up the *voids*, the open spaces, between the stones, and bond them together.

Estimating concrete is very easily illustrated. For example, a wall 10 feet long, 4 feet high, and 9 inches thick is to be built of 1-2½-5 concrete. The cubical contents of this wall is 30 cubic feet. Thus, 30 cubic feet of crushed stone will be required for the job, 15 cubic feet of sand, and 6 cubic feet, or 6 bags, or 1½ barrels of cement.

Converting cubic feet into loads, tons, or other capacities is a matter of referring to some table of weights and measures. Four sacks of 94 pounds each constitute a barrel of cement, and for the convenience of estimating proportion and quantities a bag of cement is considered to represent a cubic foot. In reality it is a trifle less.

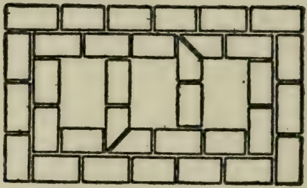


Fig. 25.—Plan of brick chimney. Three flues, without terra-cotta linings; note that no mortar joints come opposite.

The average cost of concrete is $6.00 a cubic yard, including all labor and materials, but not the forms. The cost of the forms, the carpentry, and wooden centering will vary with each class of work. It is easy to understand that the labor and lumber required for sidewalk or ground floor construction are almost negligible, since the earth itself acts as a form. For wall construction the carpentering work and lumber will average $4.00

for every cubic yard of concrete. For floor work, other than ground floors, just mentioned, which is the most expensive save ornamental work, the forms or centering will probably cost the same per cubic yard as the concrete, or $6.00. In addition to this you must consider the necessity for metal reinforcement, which will cost about 2 cents per pound. The subject of concrete is taken care of in detail in a succeeding chapter.

CHAPTER III

STAKING OUT THE STRUCTURE AND BUILDING THE FOUNDATIONS

AFTER carefully considering the questions of exposure, drainage, accessibility, the relation of other buildings or conveniences, and all other factors that might govern the selection of a site, you decide upon the approximate position of a proposed structure. The first real step toward its erection is to stake it out. In other words, the precise location of the corners of the building must be laid out on the ground with stakes, so that when lines are drawn from these points the exact boundaries of the cellar or foundation are indicated and work may be commenced on the excavation.

Devote plenty of time to this part of the work. No matter how small the building may be, "staking out" is of the greatest importance. If a structure is started out of its true position it will cause an endless amount of trouble, not to mention increased expense by reason thereof. If the corners are not right angles, every part of the structure, from foundation walls to the roof, will be out of square, and will have to be cut or built on a bevel.

Take my word for it, there is nothing more troublesome, nothing so likely to arouse the unsanctified portions of your vocabulary, than to erect a building out of square. Unless it be to build one out of plumb, which is the same thing as being out of square, only in another direction—vertically instead of horizontally.

LAYING OUT CORNERS

In a building of great size, or where the work is exceedingly involved, it is advisable to "stake out" with engineering instruments, a transit and rod, which will insure the accuracy of the lines and angles in the shortest possible time. For ordinary purposes the work can be done satisfactorily with a tape measure, preferably a steel tape, which will not shrink or stretch, and a mason's square.

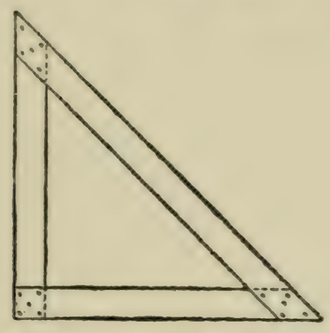


Fig. 26.—Mason's square.

The "mason's square" is a simple device, consisting of three pieces of wood nailed together as shown in Fig. 26, to form a right-angled triangle. Make the square about 5 feet long; boards 6 inches wide and 1 inch thick will do nicely for this purpose; and be sure that the square registers an exact right angle.

In laying out a building always begin with the main rectangle, or greatest part of the structure, after which the secondary rectangles, or ells and other additions, are added. Start at any point on the site where you want one of the corners to be, and drive a stake firmly into the ground. Drive a nail into the head of this stake and tie a cord to it. With this cord, which forms one side of the main rectangle, the length of which is determined by your tape, taken from the dimensions of the building, you can establish a line laid out either parallel or at right angles to a road, boundary, or other unit which the new structure is to face. When this line is determined to your satisfaction, drive a second stake, with a nail, similar to the first. The distance between the two nails must be the exact length of the side of the building, because from these nails and the line stretched between them the other corners and dimensions are established.

CHECKING A RIGHT ANGLE

With the first line as a base, the ends of the building are laid out perpendicular to it with the aid of the mason's square and tape, and so on with the remainder of the structure. To check the accuracy of any right angle without the use of a transit you can use what is known as the "three-four-five" rule. This is a useful rule; I'll explain it: A triangle whose sides are 3, 4, and 5 feet long, or multiples of these dimensions, is an exact right-angled triangle, the right angle being between the 3-foot and 4-foot sides.

BATTER BOARDS

After you have laid out all the corners and proved them to be correct, "batter boards" are erected 4 or 5 feet back from the corner stakes. These consist of boards, 4 or 6 feet long, as the case may require, securely nailed to pieces of studding or joists, which are firmly driven into the ground at right angles to each other, as shown in Fig. 27.

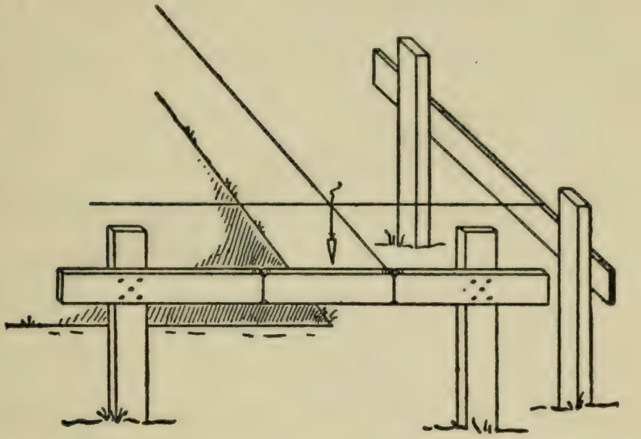


Fig. 27.—Batter boards are reference points for stretching lines, from which all principal dimensions are measured.

Batter boards are for stretching lines, indicating the size of the excavation, foundations and footings, and the outer and inner faces of all walls. They are reference points, in fact, from which all principal dimensions are measured, consequently they must be set up securely, and not likely to be displaced during the progress of the work. Once the various lines are accurately drawn, notches are cut in the batters, or nails are driven into the top edges, and marked with crayon. This establishes a permanent record. Wherever possible the top edge of the batter boards is made to indicate a certain level, usually the top of the cellar wall.

With the boundaries of the cellar and foundation walls clearly indicated, the work of excavating should proceed without difficulty. Instruct those in charge of this work where the excavated material is to be deposited, taking care to allow ample space in the vicinity of the building for timber and other structural materials. Don't make the mistake of cluttering the ground immediately surrounding the excavation. It will prove costly in the time lost hampering your mechanics.

INSTRUCTIONS TO MASONS

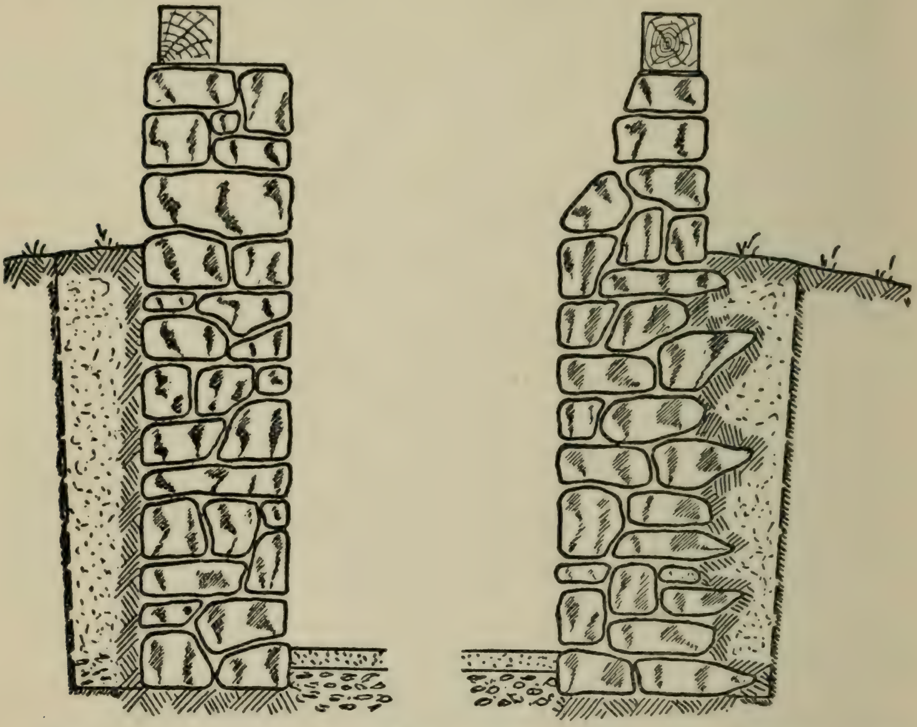
While the excavation is going ahead the materials for the foundations are carted to the site. If there is stonework this is a good time to inspect this material. Large round boulder stones should be split before being used, and stones which appear slaty or cracked should be rejected, since these are likely to admit water. The soundness of stones is easily determined by striking them with a hammer, observing if they ring.

Instruct the mason to use the largest stones for the foundation course, and to lay them as far as possible on their natural bed. That is, lay them with the strata or grain of the stone in a horizontal position. Impress upon him the need for filling every joint and all spaces between the stones with mortar, and to keep such spaces as small as possible. The object of mortar is not alone to bond and hold the stones together, but to equalize the pressure from above by providing a uniform distribution of the weight.

LAY WALLS TO A FACE

By all means have the walls built free from the bank, and laid to a line on both faces, inside and outside. (See Fig. 28.) Sometimes walls are brought to a face on the cellar side, but on the outside, up to grade level, no attempt is made to lay the work to a line. Instead, the "tails" of the stones project irregularly, some of them resting against the bank, and others barely filling out to the required thickness of the wall. This is poor construction for several reasons. In the first place, with a rugged surface it is impossible to cement the outside surface of the wall and thus make it waterproof. Then again, the projecting ledges of stone serve to catch the water which runs down on the outside, and lead it into the heart of the wall, thence into the cellar. Furthermore, any settlement of the ground on the outside, or any upward heaving by frost action, will tend to overthrow the wall by reason of the bearing against the projecting stones which tail into the ground.

It is more important to have the outside surface of a wall laid smooth and impervious to moisture than the inside face. Contractors will tell you they can plaster the inside face of a wall and make it watertight, even against pressure from without. Maybe they can, but common sense teaches us the proper place to do waterproofing is on the outside.



Good construction, containing bond stones, both faces laid to a line.

Poor construction, without bond stones, no line to outer face.

Fig. 28.—Cellar walls.

BONDSTONES

See that bond stones are laid at regular intervals, and that the vertical joints in the masonry are alternated as much as possible. (See Fig. 29.) Bond stones are those that extend the entire thickness of the wall, and serve to tie the wall together. There should be at least one in every 10 square feet of wall. Each stone should be well bedded in mortar, and properly settled by tapping with trowel or hammer. Large stones which cannot be lifted into position by hand should be set by a derrick, and not rolled into place on planks.

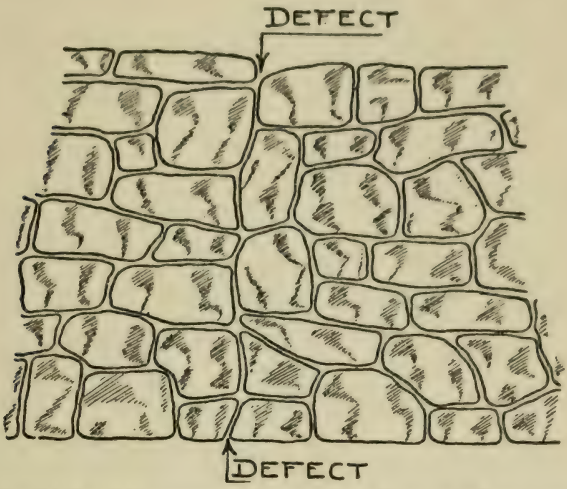


Fig. 29.—Vertical joints in masonry must be alternated as much as possible.

MORTAR

Now a word or two concerning mortar. Ordinary mortar is composed of sand and lime mixed into a paste with water. The usual proportion is 1 part lime to 4 parts sand. When cement is substituted for lime, the mixture is termed cement mortar. The customary proportion is 1 part cement to 2, 3, or 4 parts sand, depending upon the nature of the work. For ordinary purposes a 1-3 mix is used. The addition of a little lime putty, not exceeding 10 per cent., will make cement mortar work more smoothly, and it is especially desirable in cold weather.

The sand used should be clean, sharp, and coarse. By clean we mean that it should be free from loam, clay, or organic matter. By sharp, the grains should be angular, and not rounded and smooth, as those from the seashore. The term coarse means large grained, but not too uniform in size. The more uneven the grains, the smaller will be the amount of voids between them, consequently the less cement is required to bond them together.

There are many brands of cement on the market, and most of them are so well known that for ordinary purposes it is only necessary to see that the sacks bear the name of the brand specified and that their contents are fresh and in no way affected by moisture. We would select a brand that is guaranteed to meet the United States Government standard. Needless to say cement must be stored in a dry place, as even dampness will cause it to set, and it is then worthless.

The water used in mortar, and the same rule applies to concrete or any form of cement work, must be free from mud, vegetable matter, and other impurities. The quantity required to mix a given batch must be determined by actual experiments. Some grades of sand require more water to saturate them than others, and the purpose for which the mortar is intended must be considered. First thoroughly mix the cement and sand in a dry state, then add sufficient water to work the mass into a uniformly plastic condition, a consistency that can be manipulated freely under a trowel.

The secret of good mortar is to have the ingredients so thoroughly mixed that no two grains of sand shall lie together without an intervening coating or film of cement to insure perfect adhesion.

Mortar, also concrete, should be mixed in a box or on a platform; never on the ground. And the ingredients should be measured, not guessed. Use a measuring box or check the number and capacity of wheelbarrows that may be used to haul the materials to the mixing platform. This is a little more trouble, but it is the only way to obtain uniform quality.

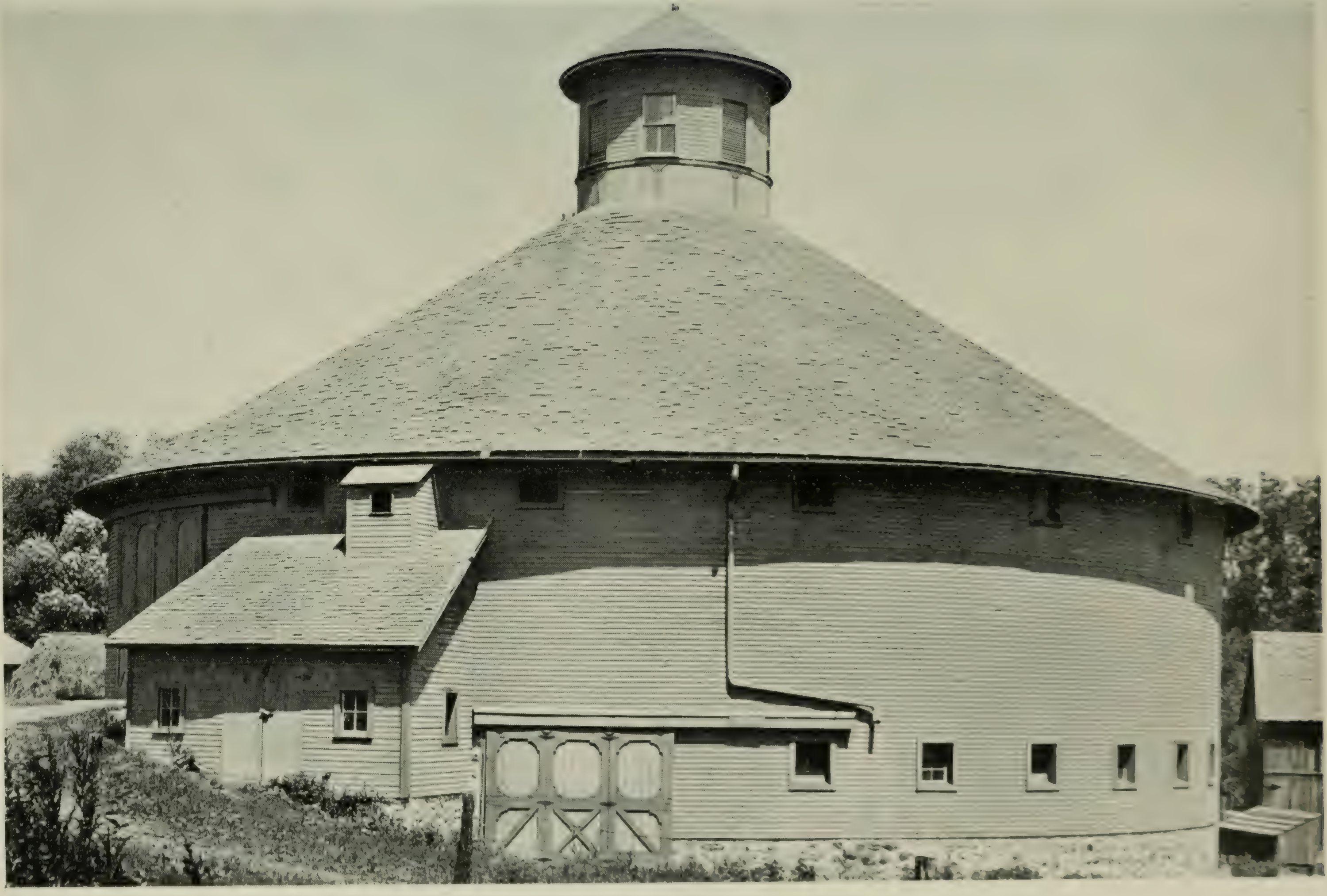
DON'T ALLOW MORTAR TO STAND

Don't mix a large quantity of mortar or concrete, with the idea of saving labor, and then allow it to stand for a considerable time before using. Don't even mix the sand and cement dry and allow it to stand, ready for the final mixing with water. The chances are the sand will be damp, if not actually moist, and this moisture will cause a partial setting of the cement, and thus impair its strength for final use. Only sufficient mortar or concrete should be mixed at a time as may be used before the cement takes its initial set. As a general rule, a half-hour is a safe time limit.

Sometimes masons will mix large batches of mortar, and if they become stiff before being used the masons will add water and remix or rework the material into a plastic condition. This is called retempering, and as a general practice it should be condemned. It is seldom permitted on engineering work of importance. Once the mortar stiffens it indicates that the cement has taken its initial set. If the mortar is then disturbed and retempered the cement is less active and cannot be expected to develop its proper ultimate strength.

A careless practice, one that may fool the constructor if he is not wise to the trick, is to employ a laborer to temper the mortar continuously so that it never has a chance to take on the appearance of setting. Mortar thus worked looks well, but the truth of the matter is it may have all the life worked out of it; for constant tempering will "kill" cement.

Concrete is extensively used in foundation work of every description. It can be made to take the shape of a column, wall or arch, or any other receptacle, no matter how irregular, into which it is poured. Almost any material that will hold concrete in place will do for a form. Foundations for many farm buildings require shallow walls, for which it is a common practice to dig trenches and use the earth banks for forms. Or, in the case of deeper excavations, if the soil is firm the bank



Circular dairy barn with silo in the center

may be used for one form and a wooden partition built for the other, as shown in Fig. 30.

FORMS FOR CONCRETE

Forms—centering—as they are usually termed, while they are false work and afterward removed, should be securely built of fairly good material. They should be strong enough to hold the weight of the concrete without bulging out of shape. When they bulge cracks occur between the planks, which cause leaks, since the mortar or liquid portion of the mixture will force its way into these crevices. This weakens the concrete and causes hollows and "fins" on the surface which look badly after the forms are removed.

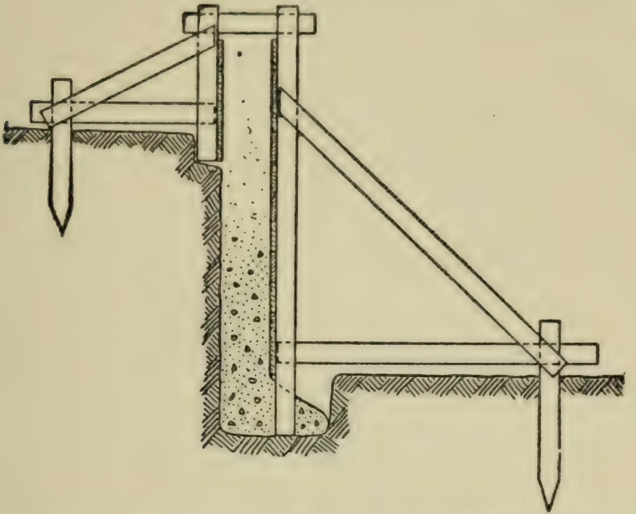


Fig. 30.—Forms for concrete wall, using earth bank for one side.

In planning forms much of their construction depends upon the nature of the job. For large structures you should count on using the forms over and over again, which greatly reduces their cost. Obviously, they should be simply framed in sections best adapted to the work, and in sizes that are convenient to handle. If they are to be used many times, tongued and grooved lumber, free from conspicuous defects, warps, and twists, is an economy. If they are for work afterward to be covered with a finishing coat of cement, it does not matter if the boards have a smooth surface, but the forms should have an accurate alignment. If a smooth surface to the concrete is desired the boards should be dressed, planed. If, however, the job is a small one, and the boards are to be used only once, and the finished appearance of the concrete is unimportant, almost any old plank or board will do, providing it is strong enough. Any cracks or knot holes may be stopped with battens or shingles.

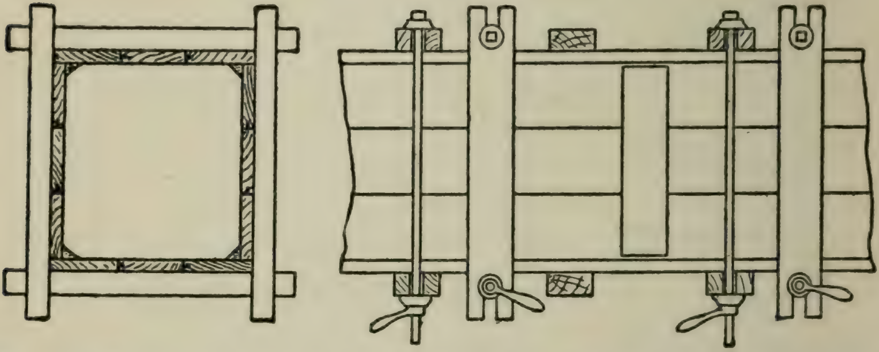


Fig. 31.—Concrete forms with locking device. These forms may be used many times.

Metal locking devices for holding wooden forms in position, in fact, complete metal forms, sockets, and many other labor-saving appliances may be purchased for modern concrete work. Unquestionably it will pay you to investigate these supplies before starting the work; write to the manufacturers of contractors' equipment. and visit the supply houses and dealers.

DRAINING THE CELLAR

Draining a cellar or basement and keeping the walls waterproof is next in importance to making the work sufficiently strong. This should be taken up in connection with the excavation. If there is no sewer connection available, which is hardly likely in the country, the cellar floor should either be built on a drainage foundation or fitted with a drain connecting with dry wells, a cesspool, or some other means of distributing the water.

For a drainage foundation excavate to a depth of 16 inches below the finished floor level, and fill it in with 12 inches of broken stone, clean large cinders, broken tile, brick-bats, or other hard, porous material that will obtain perfect drainage. Never use ashes. Tamp this foundation material to a solid bed; it is then ready for the concrete floor slab, which should be about 4 inches thick. If the cellar is located in particularly wet ground and conditions seem to warrant further precautions, a line of agricultural tile, with open joints, may be laid through the foundation material and led away from the building about 100 feet to a hillside, lower ground, or to a dry well.

The ordinary concrete floor should consist of 4 to 6 inches of cinders or broken stones, well tamped, then covered with a 3- to 4-inch slab of concrete mixed in the following proportion: 1 part cement, 2½ parts sand, and 5 parts crushed stone, pebbles, cinders, or slag. The floor should have a finishing coat of cement, pitched to drain for cleaning purposes, and provided with a cast iron stable drain or grid, which should be connected with tile or sewer pipe to carry off the water.

DRY WELLS

As a part of the drainage system of a structure you must provide for the disposal of the rain-water from the roof. If you have no intention of collecting it in a cistern, and it is not a good plan to have this great amount of water pass into the cesspool or sewage disposal plant, you should lead it away from the bottoms of the rain-water conductors by means of agricultural tile or sewer pipe to dry wells. These are excavations some 5 or 6 feet in diameter, and as deep as the case requires, with walls built of dry rubble masonry—that is, stonework laid without mortar, through which water quickly filtrates. Another type of dry well is built after the manner of a French drain, which consists of an excavation filled with loose stones, which are piled around the end of the inflowing drain pipe and the whole covered with grading.

The point that I wish to bring out—these same dry wells or French drains can be utilized to dispose of the water from basement floors, areaways, and other sources where the water is of a comparatively clear nature. They must not be used for sewage. And the drainage from stable floors should be collected in a special cistern or watertight manure pit.

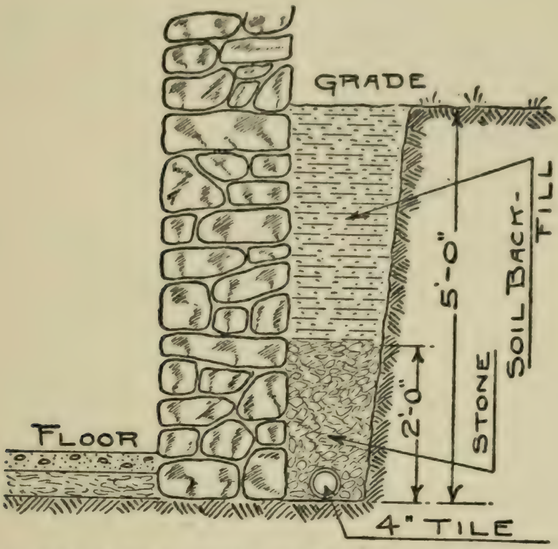


Fig. 32.—Method of safeguarding cellar walls against surface water.

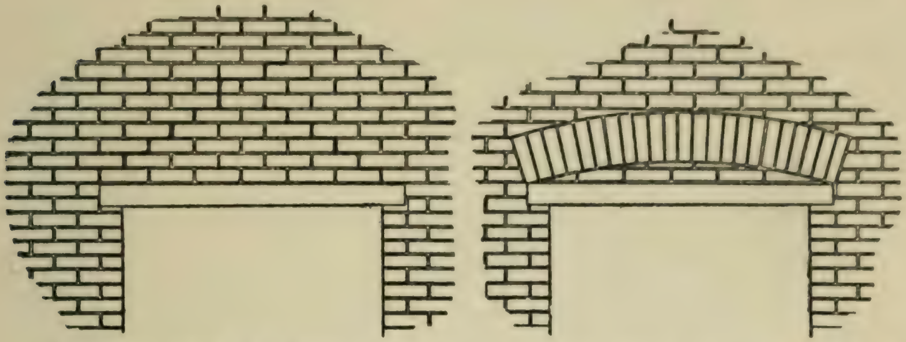
Another practical method for safeguarding cellars against surface water, one that is employed by the foremost architects and builders, is to create a French drain of broken stone at the bottom of the walls and footings, and to carry off the water in open-jointed terra-cotta tile. The tile and stone are laid as soon as the walls are completed, and really constitute a part of the "back-filling." If the stone is available on the premises, this method is quite economical, for the tile can be purchased for about 5 cents a lineal foot, and only common labor is required to lay it.

DAMP-PROOFING

If the masons were none too lavish with mortar in laying up the stonework, and there is likelihood of moisture penetrating the walls, the outside surface should be damp-proofed. First porridge the wall with plain cement mortar so as to bring the surface fairly uniform, then give it a coat of cement plaster mixed with water containing some reliable cement waterproofing compound. These compounds may be had at reasonable cost in either paste or powder form, and are designed to close up and seal the pores in the cement. The waterproof plaster should be applied not less than ½ inch thick, preferably ¾ inch thick, put on in two coats, and worked continuously, without breaks or irregularities to impair the bond.

On new work this waterproof plastering will cost about 35 cents per square yard, which includes both labor and material, but not the work of porridging the wall.

Concrete walls or floors may be damp-proofed by mixing the concrete with water containing a waterproofing compound, or by giving the work a finishing coat of waterproof cement, similar to plastering for stonework. Another method of waterproofing masonry is to apply a membrane of felt and pitch, as used for the foundation of a slag roof: Thoroughly mop the surface of the masonry with pitch, embed a sheet of heavy felt paper, mop this paper with pitch, apply another layer of paper, repeating the process until four or five ply of felt have been used, with their edges overlapping, and then cover the exposed surface with pitch. When properly done this method is positively waterproof and will not suffer from contraction and expansion.



Improper way, shrinkage of lintel is pretty sure to cause undue settlement and cracks.

Correct way, relieving arch of brick over the lintel takes the weight above and prevents settlement.

Fig. 33.—Spanning openings with wooden lintels.

CHAPTER IV

FORMULAS AND FACTS FOR CONCRETE CONSTRUCTION

WITH the introduction of concrete as a structural medium, it is interesting to note the development of mechanical achievements hitherto impossible with any other building material.

The fundamental laws of architecture are based on two great principles or themes: the column and superimposed lintel, and the arch. The Egyptians, followed by the Greeks, were exponents of the former; witness the relics of their houses and temples; and it remained for the Romans to learn that great spans could be successfully bridged by an arch ring of stones bearing upon collossal buttresses. In medieval periods there developed another phase of the arch, the Gothic school, whose masterpieces of design have never been surpassed for magnitude, exquisite beauty, and charm. All succeeding classes of architecture are modifications or adaptations of these two principles.

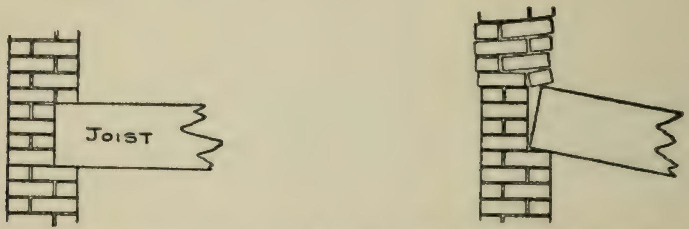
The extensive employment of concrete marks a new era, however, inasmuch as it is a radical departure from the ancient principles; or, rather, it is an embodiment of the classic column and arch with valuable added features. Concrete is something more than a column and an arch—it is a composite whole, a monolith—possessing the compressive resistance of masonry, with the tensile strength of the steel that may be embedded in it. Above everything else, it is economical, durable, and simple to construct, and for these reasons it is admirably well suited to farm use: for culverts, feed troughs, cisterns, foundations, floors, walls, fence-posts, walks, cellars, and numerous other things of which every farm is in need at one time or another, and usually built by the farmer himself. Anyone who can handle a hatchet and saw and build a wood form is competent to execute a first-class concrete job.

KINDS OF CEMENT

Cement, which is the basis of concrete—and the terms have come to be used interchangeably—is divided into two general classes: natural or Rosendale, sometimes called hydraulic, and Portland. The processes are well known and there are no patents to restrain anyone from their manufacture. Natural cement, as the name implies, is a product direct from the earth burned to a high temperature, and from the resulting clinker the finely powdered cement is ground. Portland cement is a scientifically proportioned mixture of silica, alumina, iron oxide, magnesia, and lime—virtually the same ingredients as the natural product—which are likewise burned to a clinker and then ground to powder. On account of its uniformity, however, and the low cost of production Portland cement has practically displaced the natural article; consequently, when reference is made hereafter to cement, it will mean the Portland variety.

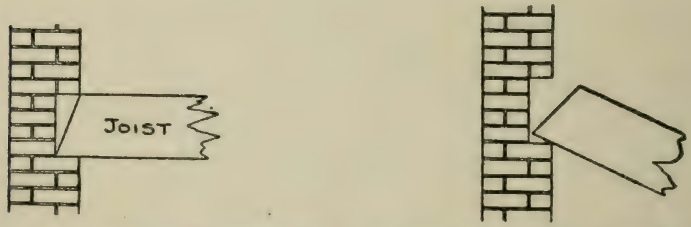
PROPORTIONING THE INGREDIENTS

For the purpose of economy various sizes of crushed stone or pebbles, technically known as the larger aggregates, are mixed with sand in varying proportions to produce concrete. It has also been found that a plain cement and sand mortar is not so strong under compression as mortar mixed with crushed stone or pebbles. Therefore, the principal requisite in concrete lies in



This is the wrong way to seat a joist or beam, because—

if the beam falls it will overthrow or injure the wall.



When a joist or girder is seated on a wall it should be cut in this manner, then—

if the beam fails it will fall away clear without injuring the wall.

Fig. 34.—Improper and proper ways to seat a beam.

making the mortar sufficiently rich to bind together the larger aggregates and to completely fill all voids to the requisite density. The correct proportion of cement depends upon the character of the other materials and the purpose for which the concrete is intended. For reinforced and damp-proof concrete that proportion is necessary which produces the most dense concrete, and a 1-2-4 mixture is generally used. If compressive strength alone is desired, the concrete may be proportioned 1-2½-5, and for massive foundations a 1-3-6 mixture may be used.

To determine the percentage of voids in any aggregate, fill a vessel of known capacity with the sand or crushed stone in a dry state; then add sufficient water to saturate and cover the material, and the amount of water required, which has been lost by absorption in the aggregate, plus 10 per cent., is the correct percentage of voids.

SAND AND STONE

Sand for concrete should be clean, hard and sharp, and the grains should not exceed ¼ inch in size. Very fine sand is not good, as it makes a soft concrete; and the presence of dirt is also objectionable. To ascertain if the sand contains loam, wash a shovelful in a bucket of water; if the water becomes muddy the sand is unfit to produce prime concrete, and should be washed.

Gravel as it is dug from a pit rarely contains the correct proportion of sand and pebbles, therefore it should be screened and graded. All material smaller than ¼ inch is considered sand, and 40 per cent. is the correct proportion. Pebbles that will not pass through a 1¼-inch screen are usually discarded. They must not contain decayed stone, and if dirty they should be washed like the sand. Gravel deposits are frequently found in creek beds and at the foot of hills and slopes where soil erosion has taken place. The ideal crushed stone for concrete is trap rock, granite, and hard limestone, those that break into sharp, angular pieces, to which mortar easily adheres. Shale, slate, sandstone, and very soft limestone are of little value. Sand, gravel, and crushed stone will vary in weight from 90 to 110 pounds per cubic foot.

CINDERS AND SLAG

For fireproofing, roofs, concrete fills, and other purposes requiring low stresses cinder concrete may be used economically in the proportion of 1-3-5. The cinders should be a hard vitreous clinker, free from sulphides, unburned coal, and ashes. Slag is another valuable aggregate frequently used in floor construction because of its saving in weight. Reinforced stone concrete weighs about 150 pounds per cubic foot, whereas cinder and slag concrete will run about 90 pounds to the cubic foot. This is an important saving where wide spans are to be considered. Slag has an excellent tooth or surface for binding with the mortar, and should be mixed in the same relation as crushed stone.

MEASURING BOX

In preparing a batch of concrete the ingredients should be carefully measured by volume, otherwise it is impossible to produce a texture that is homogeneous and uniform in appearance. For a small operation the bottomless box, as shown in Fig. 35, is a convenient method. The dimensions of the box are figured for a 1-2½-5 mixture, using two bags of cement, or what is commonly termed a "two-bag mix." Fill the box twice with the large aggregate, once with sand, and then spread on the cement. The finished product will approximate 10 cubic feet of concrete, which is virtually no greater than the cubical contents of the large aggregate. The sand, cement, and water have all gone to fill up the voids.

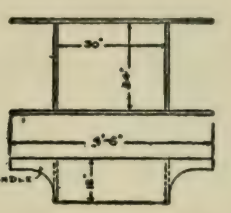


Fig. 35.—Measuring box.

For large operations a power-driven mixer is essential and the saving of labor will unquestionably warrant the investment. There are many types on the market, having electricity, gas engines, or steam as their motive power.

WATER REQUIRED

The volume of water necessary to mix a batch of concrete depends upon what water is required to saturate the aggregate, and the consistency required of the concrete for a given purpose. Where concrete is poured in a form, as, for example, walls, floors or foundations, and for reinforced concrete, the mixture should be "mushy"—of a consistency that may be poured readily from a wheelbarrow or bucket. A thoroughly wet or "sloppy" concrete will completely fill all spaces in the forms and may be depended upon for securing a perfect bond with metal reinforcing and for producing a dense, waterproof texture. A dry concrete, that which has the plasticity of a stiff mortar, and which is frequently used for ornamental work, produces a working strength more quickly than wet concrete and the forms may be removed sooner; but ultimately, when it has thoroughly cured, it will not have the compressive nor tensile strength of the wet mixture. For certain effective surface treatments, which will be described later, the dry

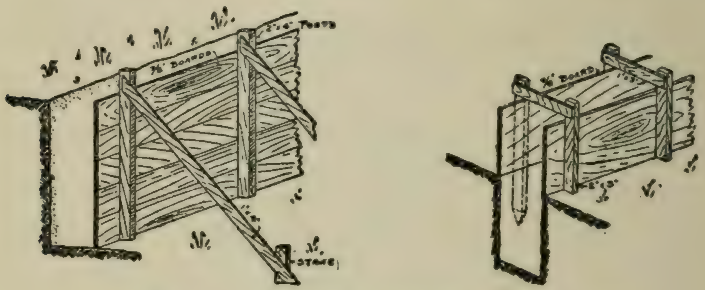


Fig. 36.—Forms for concrete walls.

state is necessary. In all cases, however, what water is used should be free from oil, alkali, and vegetable matter. If it is fit to drink, it is fit for concrete.

ADHESIVE ACTION OF CEMENT

The difficulties encountered in concrete work are often attributed to defective cement, when, in reality, they are more frequently due to improper handling. Concrete, or any other form of cement work, is a distinctly perishable commodity, inasmuch as it must be deposited in its permanent position almost immediately after the water has been added. No longer than half an hour should elapse before it is entirely disposed of, and no amount of reworking or retempering will preserve it. The adhesive action of Portland cement is instantaneous, and if disturbed during this period of "initial set" its adhering quality is destroyed. Obviously, if the mixing process is slow and extends over too long a period of time, the cement will be "killed."

FLOOR CONSTRUCTION

In sidewalk and floor construction, where a smooth surface is desired, it is more economical to use a 4- to 6-inch concrete foundation slab covered with a 1-inch finishing coat of cement mortar. Mix the cement with 1½ to 2 parts sand, and if practicable apply it to the concrete while the foundation slab is yet green. There is a tendency among those who are inexperienced to use too much cement in a finishing coat; yet it is well to remember that a mortar which is too rich in cement is apt to "check" or "craze," and thus ruin the appearance of the surface.

EXPANSION JOINTS

On roof construction, particularly if the area is large, provision must be made to safeguard against cracks developing from expansion and contraction, which may be obviated by putting in expansion joints, as shown in Fig. 37. V-shaped pieces of copper—tin is not durable—should be placed on the centering and embedded in the concrete as it is poured, and with it an inch batten stood vertically, so that the upper edge projects above the finished surface of the slab. When the concrete has set the battens are removed, and later, when the slab has hardened, the joints are raked clean and filled with asphalt mastic cement or bituminous mastic.

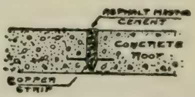


Fig. 37.—Expansion joint.

STRENGTH OF CONCRETE

The compressive resistance of plain concrete is about ten times greater than its tensile strength, therefore, if openings are to be spanned, this discrepancy must be made up by a steel reinforcement of some kind. Any beam or floor slab which takes bearing at its ends, is unsupported in the middle, and sustains its own weight and a load, is subject to deflection or bending; hence transverse stresses are created. These stresses are both compressive and tensile, as shown in Fig. 38, and if they exceed the elastic limit of the fibers of the concrete, the work will rupture and fail. The stresses above the neutral axis are crushing strains, as noted in the upper section of diagram, while those below the axis are tearing strains; and since the tearing or tensile resistance of concrete is one-tenth its compressive strength, the reinforcement is added in the lower section to make up for this deficiency. Reinforcement is also necessary in walls, columns, or piers to prevent buckling or shearing, especially where the height of a wall or column is greater than ten times its thickness or diameter. A wall 12 inches thick would safely support its own weight up to 12 feet in height; but if then made to support a heavy load, or made appreciably higher, it would buckle unless adequately reinforced.

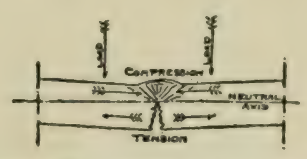


Fig. 38.—Diagram of stresses on concrete slab or beam.

REINFORCEMENT

Heavy wire or plain round bars may be used successfully for reinforcement; yet there is a preference for some type of bar that is deformed or rolled with an irregular surface—which affords a greater bond with the concrete. There is a wide variety of these bars on the market, some of which are patented; but the "square twisted" bar is the most extensively used, and usually the cheapest, for there is no patent on it. They may be purchased in almost any size, either in stock lengths or special lengths, and the average price is 2 cents per pound; ⅜-inch bars are the most commonly used, except in very massive construction, and such a bar weighs a little more than ⅓ pound per lineal foot. Ordinary fence wire or wire netting may be used on light work or where secondary or transverse reinforcement is required.

Whatever kind of reinforcement is used, it should first be cleaned free of any loose rust, scale, oil, or dirt; for foreign matter of this kind will prohibit a perfect bond, and therefore renders the reinforcement useless. The precise amount of reinforcement necessary is ascertained only by engineering principles and theories which involve rather intricate calculations, and as every case is designed to meet specific requirements, it is impossible to establish an invariable rule. For ordinary work, however, the following is a good rule of thumb: Provide ½ pound of steel for every square foot of wall construction, and ⅔ pound of steel per square foot of floor construction.

DANGER OF FREEZING

The construction of exposed concrete should be avoided as much as possible in winter weather; yet if such work is imperative, good results may be secured by lowering the freezing-point of the water, or by heating the materials entering into the concrete and subsequently protecting it by salamanders or sheet-iron stoves. It is safe to mix concrete in a temperature of 30° F., or where there is no alternate freezing and thawing for the first forty-eight hours, when it is then out of danger from frost. The use of ordinary salt is the most economical method of reducing the freezing-point, wherein 1 pound of salt to every 100 pounds of water is required for every degree of temperature lower than 30° F. The maximum, however, should not exceed 10 per cent. salt, as a greater quantity is apt to injure the strength of the concrete, or there is likelihood of the salt corroding the steel reinforcement. Moreover, this treatment is not advisable where the final appearance of the surface is

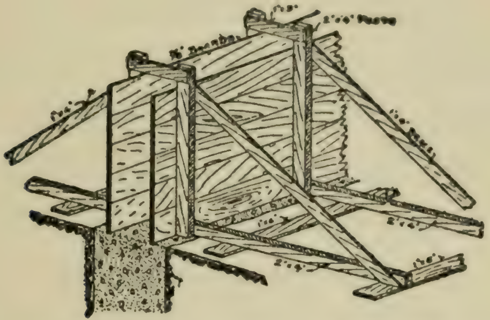


Fig. 39.—Forms for concrete wall above ground.

important, for the salt is likely to show in white spots or streaks.

A hot summer sun or extremely high wind is equally injurious to green concrete, for the surface is then dried out in advance of the interior, and will thus impair its strength and appearance. Where these conditions prevail, the exposed surface should be protected by boards, canvas or straw, or by intermittently sprinkling the surface with water for the first thirty-six hours.

FINISHING THE SURFACE

In house construction, or where an attractive exterior surface is desired, it is not necessary that the concrete should present a cold, severe, leaden appearance—such as sidewalks or railway piers. On the contrary, a wide variety of soft, pleasing effects may be attained by simple mechanical treatments. The surface may be scrubbed when green with a stiff fiber or wire brush, or washed with a 10 per cent. solution of commercial hydrochloric (muriatic) acid, which removes the outer cement fiber and exposes the texture of the large aggregate. A terrazzo effect may be obtained by rubbing the surface with a carborundum stone, which not only removes the cement fiber, but grinds and polishes and brings out the rich colors of the aggregate. This may be selected from numerous marbles, granites, sandstones, or gravels to produce an appearance that will harmonize with some general scheme. Sand-blasting is also effective, and marked individuality and character may be given an otherwise flat, monotonous surface by tooling it with a brush hammer. By using a fairly dry concrete and tamping thoroughly a surface will be obtained that has all the warmth, texture, and softness of a coarse-grained stone. If the concrete is mixed lean in the finer aggregate and well tamped, the face will be rough and deeply pitted, and possess the charm and irregularity of miniature field-stone masonry.

Any of the above treatments—and there are many others—which offer wide range for ingenuity, will quickly dispel the forbidding, severe look that plain concrete usually has, and which sometimes prejudices the beholder against its use.

CHAPTER V

FRAMING THE SKELETON OF THE BUILDING

CARPENTRY is an ancient trade. Or, call it an art, whichever suits your fancy. Certainly, the cathedrals and other priceless relics of medieval times are proof that it attained such distinction. It has been practised in all ages and in all lands, and is likely to continue a boon to mankind so long as there is timber from which to contrive structures and utensils.

Under different conditions there have developed different methods of performing the same work, so that there has accumulated a vast amount of experience from which to draw and study; and while greater scientific knowledge of the natures and properties of materials has given the modern workman immense advantages over his medieval craftsman, and caused many changes in the details, the principles of carpentry remain much as they were centuries ago.

CARPENTRY AND JOINERY

To the layman, perhaps, every kind of woodwork is thought to be carpentering work. In reality, however, woodwork is divided into two main classes—carpentry and joinery. Carpentry is the structural part of a job, and includes all the rough timber-work necessary for support, division or connection, and its chief object is to create form and stability. Joinery contributes almost wholly to the comfort and utility of a structure. It includes the interior finish, the trim, stairs, and other built-in woodwork, and has for its object convenience and ornament.

Though carpentry and joinery are often followed by the same individual, the principles are not common to both trades. In carpentry the framing owes its strength to the form and position of its parts more than anything else; while in joinery the strength depends almost entirely upon the integrity of the joinings. A man may be a good carpenter without being a joiner at all; but he cannot be a good joiner without being competent to execute all the operations required in carpentry.

In erecting the framework of a structure numerous methods are employed in securing pieces of timber, and each has a particular advantage which makes it preferable in some circumstances. The underlying principles are few, however, of which we will review the most commonly used. Others are modifications, and some are employed merely to please the eye. We will not concern ourselves with those.

JOINTS AND SPLICES

Connections between pieces of timber are classified as joints or splices. The term *splice* is applied to connections in which the members extend in the same direction, as shown in Figs. 40, 42, and 46. These are necessary to piece out sticks of timber, and to provide scantlings of great length. By a *joint* we mean connections between timbers coming together at an angle,

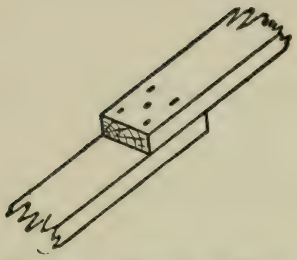


Fig. 40.—Simple splice.

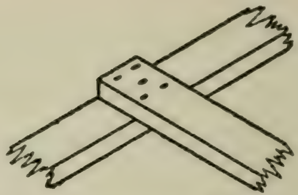


Fig. 41.—Lap joint.

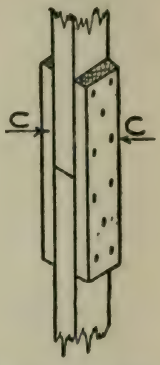


Fig. 42.—Fished splice.

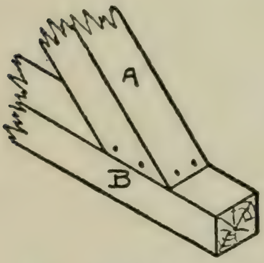


Fig. 43.—Oblique butt joint.

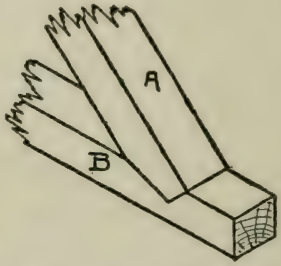


Fig. 44.—Modified butt joint.

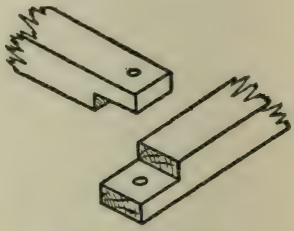


Fig. 45.—Halved joint.

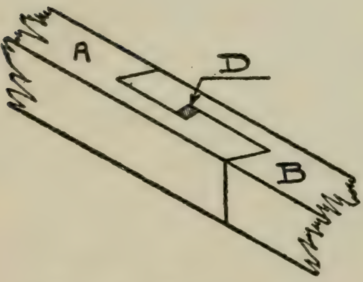


Fig. 46.—Keyed splice.

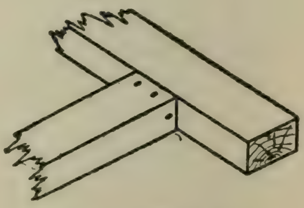


Fig. 47.—Butt joint.

JOINTS AND SPLICES.

as shown in Figs. 41, 43, 44, 47, and so on. These occur in a great many places, especially at the corners of a building, and are exceedingly various. The most generally used joints and splices are shown on p. 96.

Lapping one timber over another, either at right angles or diagonally, and nailing the pieces together, as shown in Fig. 41, is the simplest kind of a joint. Another one, equally simple, is the *butt joint*, as illustrated in Fig. 47, which is made by placing two members together, perpendicularly, and nailing them securely in the manner indicated. The nails are driven diagonally, better known as *toe-nailing*, and if necessary the heads of the nails are driven home with a nail set, or punch. The *butt joint* is used extensively in erecting the studding of a house, where the strains are imposed in a direct load from above, as in the case of a plate or sill.

When two pieces are fitted together at an angle, as shown in Fig. 43, it is called an *oblique butt joint*. The member A is cut to the required bevel and is then secured to B by *toe-nailing*, as indicated. It is apparent that the greater part of the strength of this joint depends upon the nails, consequently it should not be used where the maximum strength is required. For greater strength, especially where there is a tendency for one member to slide along the other, cut a notch in B, as shown in Fig. 44, and set A down into it. This adds very substantially to the joint, and takes the strain off the nails almost completely.

Fig. 45 illustrates a *halved joint*, so called because each member is cut half-way through and then placed together. The pieces are held in place by nails or spikes, depending upon the magnitude of the work, or by a dowel pin. This joint is used to connect the sills at the corners, also the plates. If one member meets the other near the center, instead of at the end of the piece, and there is likelihood of their drawing away from each other, the *dovetail joint*, as shown in Fig. 48, is used. The *tenon* and *mortise* are cut in the shape of a fan, or with the flare on one side only, which prevents them from being pulled apart.

From the *butt joint*, as shown in Fig. 47, it is only a step to the *mortise-and-tenon joint*, pictured in Fig. 49. This is formed by cutting a hole—called the *mortise*—in one member the exact size of the projection, or *tenon*, which is cut on the end of the other member. When the parts are assembled a hole is bored through both timbers, in about the center of the *tenon*, to receive a wooden pin or *dowel*, thus preventing the *tenon* from being withdrawn from the *mortise*. It is customary to make the pins of hardwood, about ¾ inch in diameter; though occasionally it is better to use a square pin. When properly formed this makes one of the strongest joints, and is used on work requiring heavy timbers, where it is impracticable to spike them together.

The *bridge joint*, as shown in Fig. 50, is a development of the *mortise-and-tenon joint*. It is prescribed for timbers meeting each other at an angle, as indicated in Fig. 43. It is similar to the square *mortise-and-*

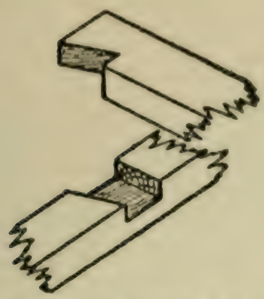


Fig. 48.—Dovetail joint.

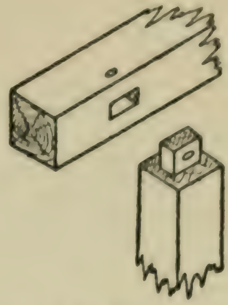


Fig. 49.—Mortise-and-tenon joint.

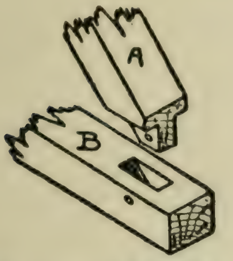


Fig. 50.—Bridge joint.

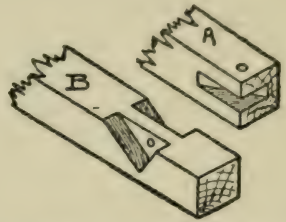


Fig. 51.—Bridge joint.

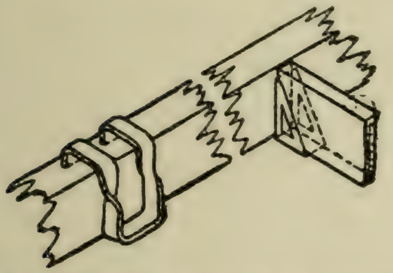


Fig. 52.—Metal hangers for beams and girders.

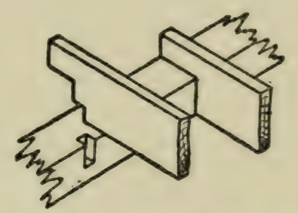


Fig. 53.—Mortising sill for floor beams.

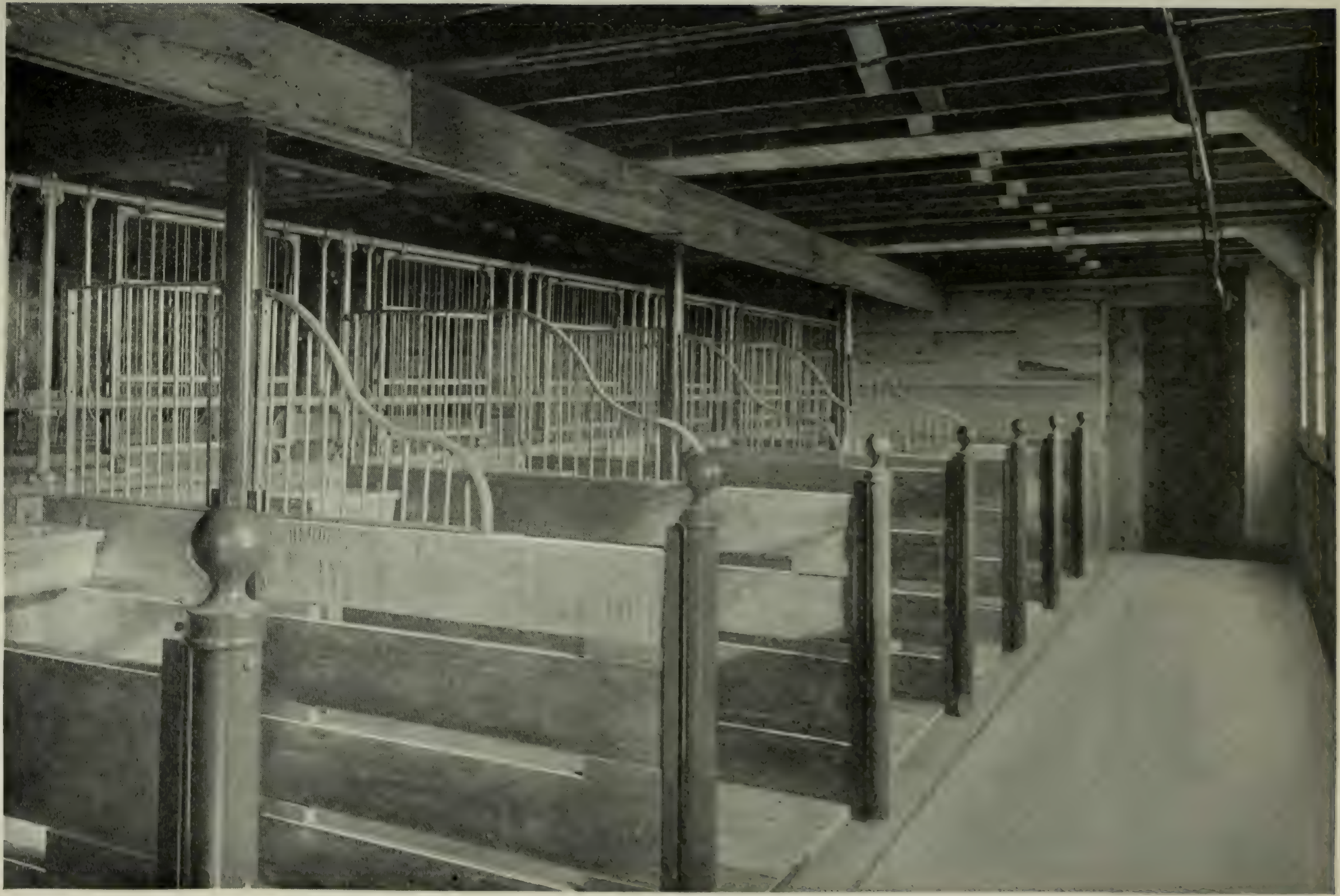
MORTISES.

tenon joint, except, since the member A is inclined to B, and not perpendicular to it, the *tenon* must necessarily be cut on a bevel.

When it is desired to reverse the cuts, so as to make the member A straddle B, rather than be inserted in B, the timbers are cut as shown in Fig. 51. This is sometimes called a *straddle joint*. These joints are used on heavy timbers, such as the braces or struts in the old-fashioned method of framing a barn. It is a staunch way of building, but also an expensive way, for considerable skill is required to do accurate *mortise-and-tenon* work. Furthermore, since the joints are only as strong as the thickness of the material in the *tenons*, when it comes to *shearing stresses*, many of the old timber frames are not so strong as they appear.

To return to the subject of *splices*, if there is no great strain on a piece of timber and, for example, it is merely being used as a brace for temporary work, it may be *pieced* or *spliced* as shown in Fig. 40. If a *splice* is intended to resist compression alone, as in the case of the uprights to a scaffolding, the two parts are cut squarely and placed end to end, as shown in Fig. 42, and held in place by a couple of pieces (C, C), called *fish plates*, hence the name *fished splice*.

For ordinary work the *fish plates* are nailed on opposite sides to keep the uprights in line. On heavy work they may be bolted. If for any reason it is found impracticable to have any projection, such as the *fish plates*, the timbers may be spliced together, as shown in Fig. 46. This is called a *keyed splice*. The members A and B are *scarfed* on a bevel, as indi-



Interior of a carefully appointed horse stable

cated in diagram, and then held snugly together by means of a hardwood *key*, D. Needless to add that very precise workmanship is required for this splice, or it fails to develop the desired strength.

FRAMING THE SUPERSTRUCTURE

After the building has been laid out, and the batter boards are set up, and while the masons are constructing the cellar walls and foundations, the carpenters commence the framing of the superstructure. This consists in preparing the skeleton, or framework, upon which the covering is placed, and later the utilities and conveniences are added, perhaps ornamental features, as in the case of a dwelling. And as the skeleton is the most essential part of the human body, in point of strength at least, so is the frame the most important part of a building, and upon which its future usefulness and durability depend.

SILL

The first part of the frame of a wooden structure to be set in place is the sill, which rests on the top of the cellar wall or foundation and extends around the entire building. Occasionally a building is erected without a sill, as in the case of some types of plank frame barns, where the trusses or frames are erected in metal sockets embedded in the concrete or stone walls. Sockets are manufactured especially for this purpose, and their use is an approved method of construction.

The preparation of the sill consists in jointing the corners, splicing where necessary, and notching out about 2 inches down from the top of the sill for each floor joist or beam. It may also be advisable to mortise the sill to receive corner posts, door and window studs. Since it is subject to considerable cutting, and sometimes made to span fairly wide openings, such as cellar windows, the sill must be of good size. Ordinarily it is made of 6 x 6 timber, or larger stuff, up to 8 x 12 material, or it may be built of several planks spiked together.

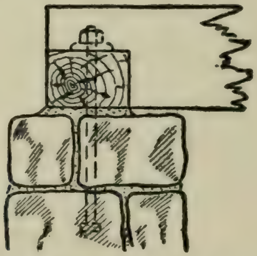


Fig. 54.—Bolting sill to foundation.

In the latter the planks should be so arranged as to alternate any joints, and placed so that the planks set upon edge and not lie flat.

The sill should be painted on the under side as a protection against moisture from the wall, and set in a thick bed of mortar, to insure a uniform bearing, and to prevent the entrance of air between the sill and the wall. The sill is usually set a couple of inches back from the face of the wall, to allow for the water table, and this ledge offers an opportunity to point up any cracks with mortar. In many cases it is found advisable to bolt the sill to the wall. At intervals of about 10 feet bolts are embedded in the masonry, which are then made to extend up through holes bored in the sill, and fastened by a washer and nut, as shown in Fig. 54. This fastens the sill, consequently the entire frame, to the foundation, and in locations exposed to high winds, especially with light structures, the practice is deemed essential.

JOISTS OR FLOOR BEAMS

The joists or floor beams, which form the framework for the first floor, together with any girders, are the next timbers to be set. They may be supported at the ends by mortising the sill, as shown in Fig. 53, or set in patent hangers fastened to the sill (see Fig. 52). By the use of hangers neither the joist nor the sill is weakened by cutting, and the cost of the hangers is offset by saving the labor of mortising.

When the joists are in place the first floor is usually laid at once. This stiffens the work, helps to shelter the basement, and, most important of all, affords a platform on which to proceed with the rest of the work. If the floor is to be double, then the under flooring or rough flooring should be laid diagonally across the joists, as this adds greatly to the strength of the building, and offers a more uniform surface for laying the finished floor.

BRIDGING

As soon as the floor is laid, and before this, if the boards are laid diagonally, the joists or beams must be bridged, as shown in Fig. 55. Another term for this work is *trussed*, or *herring-bone bridging.* It consists of pieces of scantling, usually 1 x 3 or 2 x 3 stuff, fitted diagonally between the joists, and nailed to the top of one beam and to the bottom of the next. They are placed in straight lines at intervals of 8 or 10 feet across the length of the floor.

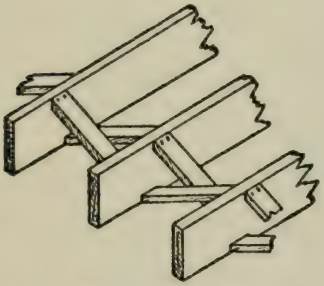


Fig. 55.—Bridging for floor joists.

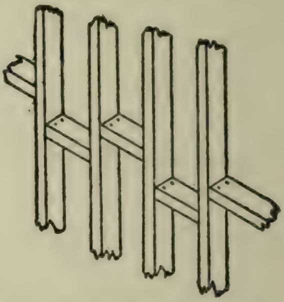


Fig. 56.—Bridging for wall studs.

Bridging stiffens the floor frame very materially, though it adds nothing to its strength as a whole. It prevents uneven deflection of the joists, and therefore eliminates vibration, since a more heavily loaded joist is prevented from sagging below the others by transmitting the excess weight to the adjoining timbers by means of the *bridging.* You might reason that pieces of plank cut off square and inserted between the joists will serve the same purpose, but this is not so. Such a method is called *plank bridging*, or *horizontal bridging*, and may be used to good effect in stiffening wall studs, similar to that shown in Fig. 56.

CORNER POSTS AND STUDS

After the first floor is covered the next step is to raise the exterior vertical frame. First the corner posts are set up and braced temporarily, then the door and window studs are added, with the girts or ledger board and the plate framed between them, and finally the whole is filled in with studding. This work should be carefully watched to see that the openings come in the proper places and that they are plumb. There is such a confusion of upright timber at this stage of the construction it is very easy to frame a door or window out of place.

In a dwelling of moderate size the corner posts are usually 4 x 4 timbers, or two pieces of 2 x 4 stuff are spiked together. For long corner posts it is better to use 4 x 8 timber. In the *balloon* method of framing a house, which is now commonly used, there are no girts, a term given to the horizontal timbers embodied in the frame to carry the upper floor joists. Instead, the studding is carried continuously from the sill to the plate, the same as the corner posts, and provision is made for supporting the intermediate floors by spiking a ledger board or *ribbon* into notches cut in the inside of the studs, as shown in Fig. 57. These *rib-*

bons are about 1 inch thick and 6 inches deep, and the floor joists are notched over them.

This newer method of construction is not so strong as the old-fashioned braced frame, wherein heavy girts and braces are used, but it is very much easier to erect, consequently cheaper.

PLATE

The office of the plate is to tie the studding together at the top and thus form a finish for the wall, and to furnish a support for the lower ends of the rafters. It may also serve as a bearing for the attic floor joists or second floor ceiling joists. The plate usually consists of a 2 x 4-inch piece, the same material as the studding, spiked to the corner posts and studding, and on top of this another 2 x 4-inch piece, breaking joints and overlapping at the corners. In heavy work the plate may require 4 x 6-inch timber, or even heavier material, mortised to receive the upright timbers, and with the corners *half-jointed*.

The studding of a house is generally placed on 16-inch centers. In especially good work the studs are placed 12 inches apart, and on correspondingly poor work 20 inches apart. For convenience the floor joists are placed at the same intervals. It is customary to make the studs the full width of the framework of the wall, which is about 4 inches in dwellings and 6 inches in barns, and 2 inches thick. At least once in the height of each story the studding should be bridged, as shown in Fig. 56, to help stiffen the walls and distribute their load.

DOOR AND WINDOW OPENINGS

At door and window openings the studs are doubled or the size timber is increased. In way of these openings it is also advisable to create a truss, as shown in Fig. 57, by setting up two pieces of studding over the opening, in the form of a triangle. The idea of this truss is to take the weight which comes from the studding directly overhead and transmit it to the sides of the opening, thence to the sill, without causing the head of the opening to sag, as it would otherwise do, unless heavily reinforced.

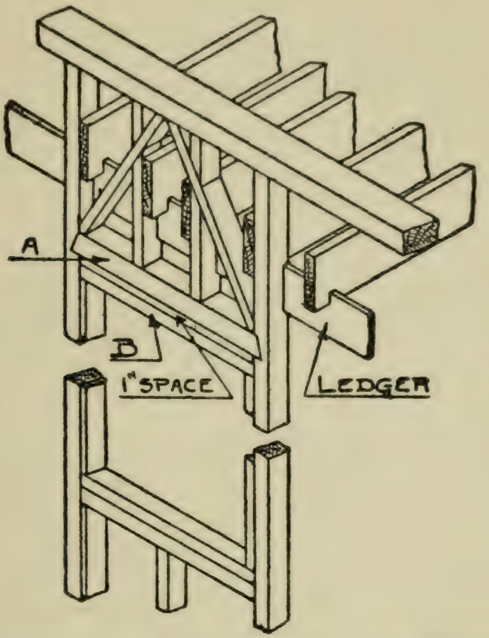


Fig. 57.—Truss over door or window opening.

A space of at least an inch should be left between the timber A, forming the bottom of the truss, and the piece B, iormfng the top of the window or door frame,

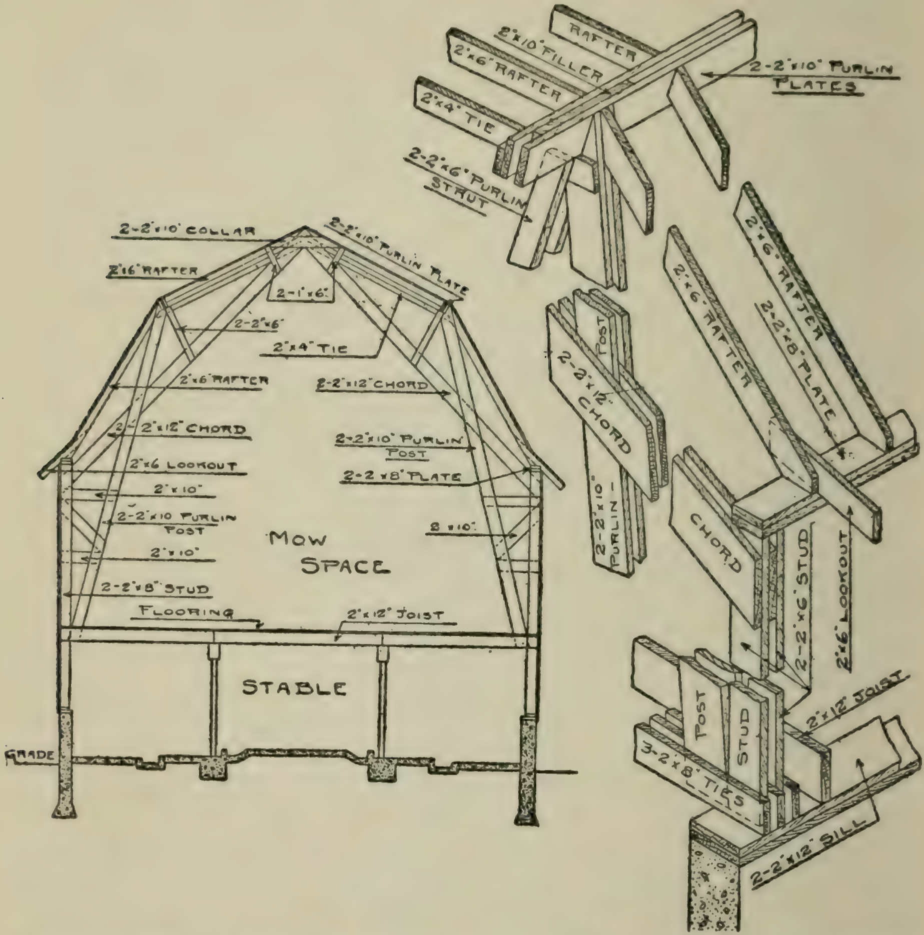


Fig. 58.—Plank frame barn construction. Self-supporting roof: Heavy trusses spaced 12 feet apart, with rafters spaced on 24-inch centers.

so that if the truss takes a slight spring it will not affect the alignment of the opening.

While we are on the subject of sagging and alignment, there is another point to be considered in connection with the framing of walls and partitions of all frame structures, and that is the settlement due to the shrinkage of timber. Lumber always shrinks considerably across the grain as it seasons, but very little in the direction of the grain, consequently it is the horizontal members, such as the sills, joists, and plates, which cause the trouble.

SHRINKAGE AND SETTLEMENT

You can depend upon it, every foot of horizontal lumber between the foundation and the roof will contract to a certain degree. And since the walls and partitions are supported by these horizontal timbers, they, too, must settle proportionately. If all the outside walls and the interior partitions settle precisely the same amount, no damage is likely to result, for the floors and ceilings will remain true and level. If, however, one side of the structure settles more than the rest, and the levels are disturbed, there will be a general racking and distortion of the entire frame, accompanied by the cracking of plaster and the binding of doors and windows. In extreme cases it may even cause the failure of parts of the frame and collapse.

There is but one way to overcome this unequal settlement due to the shrinkage of the timbers: it is to make the extent of horizontal timber uniform in all parts of the structure. Be sure to remember this point; it is too often neglected.

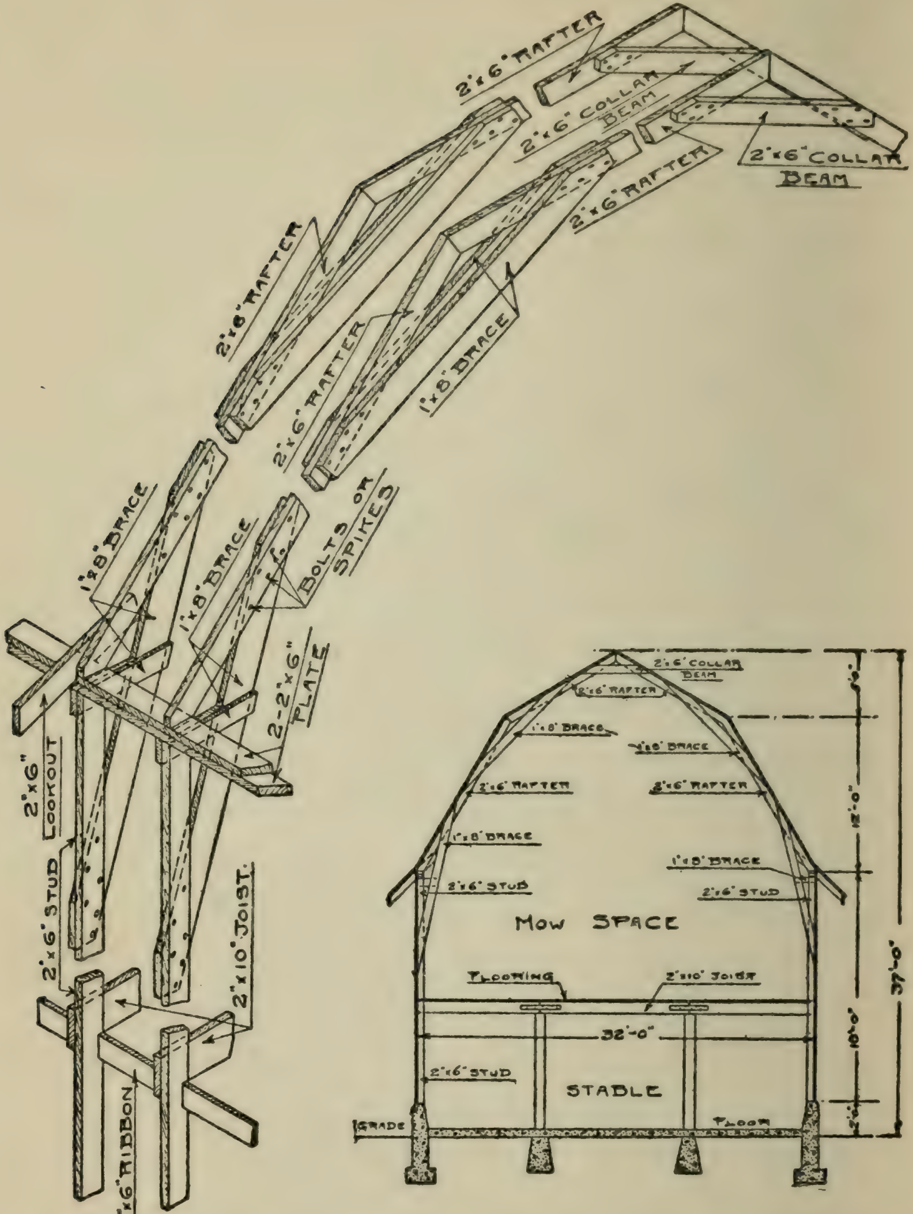


Fig. 59.—Plank frame barn construction. Self-supporting roof: Every rafter is made to form a truss, rafters spaced on 24-inch centers.

BARN FRAMING

Now for a few notes on the subject of barn framing, which differs from house construction mainly because the barn is little more than a weather-proof shell, requiring no interior finish except in the stable portions. The roof, floor and stable walls, which are the most costly factors in a barn, are virtually the same whether the building be high or low. Therefore the high barn offers greater storage capacity in proportion to cost, and means economy, particularly since the perfection of hay-carrying machinery removes any limitations otherwise entailed by attempts to store hay by hand in high, inaccessible mows.

The chief problem was to secure this increased loft capacity without the use of cumbersome timbers, and their consequent cost, and to provide mow space with open centers, which would permit the operation of a hay carrier from one end of the mow to the other. In the old-fashioned gable-roofed barns of steep pitch not only did the cross beams and heavy supporting timbers interfere with the installation of a carrier, but much valuable mow space was lost because of its inaccessibility.

PLANK FRAME CONSTRUCTION

In recent years, following exhaustive experimental work with many types of barns, there has evolved what is known as the plank frame barn, wherein nothing thicker than 2-inch planks are used for its construction.

Mostly it has a gambrel-shaped roof, which permits of a generous loft, and, what is even more vital, the loft is unobstructed because the roof is self-supporting. That is, each frame or truss in the roof creates a self-supporting arch, which when completed forms a very rigid structure, equally as strong, if not stronger, than the old-style heavy timber framing.

With the increasing scarcity of heavy timbers and the difficulty in obtaining them, except at prohibitively high prices, this newer method of barn framing has attained wide popularity. It is not alone an economy in material, since it uses timbers carried regularly in stock in all lumber yards, but it greatly reduces the extent and quality of the labor involved. As previously mentioned, the skill required to frame heavy barn timbers on the mortise-and-tenon plan is expensive; whereas plank framing merely demands that the numerous posts, ties, and braces be spiked together at the proper angle. With two or three skilled carpenters on a job of this kind, the other assistants may be handy men working as laborers under instructions.

No scaffolding is needed on this method of construction, since the trusses or frames are built on the ground, and if the right method of raising them is followed there will be no difficulty or hazard experienced. The first truss should be assembled from a carefully proportioned plan or sketch, care being taken to so stagger or alternate the joints in the different members that the truss has uniform strength. The other trusses or frames are then cut exactly like it, if necessary one on top of the other, thus insuring absolute accuracy, after which they are erected with the aid of a block and tackle. The purlins and plates are then added, and finally the sheathing boards, roofing, and siding.

The accompanying sketches in Figs. 58 and 59 illustrate how these self-supporting frames are built, and give a general idea of the timbers required. In one method every rafter or frame is made to form a truss, and the rafters are spaced on 24-inch centers. In the other arrangement heavier trusses are spaced about 12 feet apart, connected by purlins and plates, which are then framed with rafters spaced on 24-inch centers. In both framing diagrams every piece of timber has a specific purpose, and is so placed that it exerts its utmost power where the greatest strength is required.

CHAPTER VI

INCLOSING WALLS—COVERING IN THE BUILDING

IN the preceding chapter we discussed the construction of the skeleton of a frame building, together with the principles of carpentry involved in the rough timber-work, such as the sills, plates, girts, studding, floor joists, and so on. In short, we assumed to create the form and stability of the structure—the framework necessary for the support of the inclosing walls, and later the interior finish and the building's conveniences. We will now review the "covering in" of the buildings—the inclosing walls and the materials of which they may be built.

From a structural point of view, the inclosing walls of buildings are divided into three principal classes: (1) load-bearing walls, those that support their own weight and the adjacent floors and roof; (2) self-supporting walls, those that support their own weight, but no floor or roof loads, usually built of brick or stone, and have contained in them certain steel elements carrying the floor and roof loads; (3) curtain walls, those which are not self-supporting as a whole, but which are borne by a steel framework from story to story.

The second and third classes are seldom employed outside of high-building construction, such as factories, hotels, and office buildings, consequently we need only concern ourselves with walls of the first class, which are usually built of stone, brick, concrete, steel, hollow tile, or frame. As for the materials of which frame walls may be built, you may select from clapboards, siding, shingles or common boards, or combinations of these.

CLAPBOARDS AND SIDING

The term "clapboard" is used almost exclusively in New England, and corresponds to the term "siding" or weather-boards, as used elsewhere. Siding is made in various sections, usually about 6 inches wide and ½ inch thick at the butt, in lengths of 12 to 16 feet. It makes an excellent wall covering, and in good practice it is laid over sheathing boards, with building paper between, to insure greater warmth. The sheathing boards should be placed diagonally across the framework of the building, securely nailed to each stud, which greatly stiffens the entire structure. The building paper is put on horizontally, as the weather-boarding proceeds, with the edges of the course overlapping generously, and breaking joints with the paper and flashings already in place behind the finished work.

There is a kind of siding called *novelty siding*, of which there are several styles, thicker than the ordinary weather-boards by ¼ inch or more, which is sometimes nailed directly to the studding, without any sheathing boards or paper. Or it is nailed to the studding, which is first covered with paper. These methods are effectively used on many kinds of farm buildings and sheds where warmth and absolute weather protection are not required. They save on the cost of the rough boards, but it should be remembered that the omission of these sheathing boards means a loss in strength and warmth, especially if the inside of the building is to be left unfinished.

SHINGLES

If the walls are to be shingled the same care must be taken as in shingling a roof, except that the shingles may be exposed an inch or two more to the weather by reason of the increased pitch, and they may be of a quality termed *clears*, in which the lower third or exposed portion of each shingle is free from imperfections. Shingling makes a warmer wall than siding because there are always three thicknesses of shingles on the wall to one of weather-boards, but the choice is usually governed by the nature of the building and the element of cost. Cypress shingles are considered to be the most durable, though redwood and cedar, especially the latter, are more commonly used.

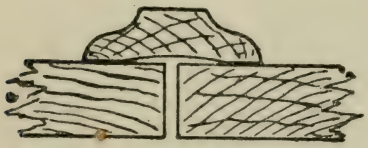
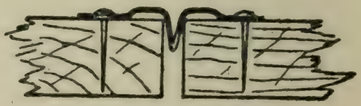


Fig. 60.—Wooden batten.



Metallic strip.

It is hardly necessary to dwell upon an explanation of the use of barn boards. They are familiar to almost everyone, and may consist of plain boards, battened with wooden or metallic strips, as shown in Fig. 60, shiplap lumber, matched boards, sometimes called *roofers*, or plain boards covered with one of the reliable brands of patent roofing.

FIRE-STOPS

In connection with the covering in of the frame, the work of fire-stopping the walls and partitions should receive attention. Fire-stops are bricks or stone masonry built up on the top of the foundation walls behind the sill to the underside of the floor, as shown in Fig. 61. They are also fitted on the tops of girders, and if the girders support partitions, the stops should be carried up between the studs for the height of two or three bricks.

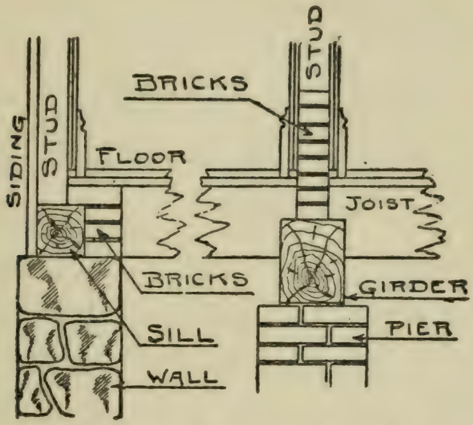


Fig. 61.—Fire-stops for walls.

This practice is not only a source of protection in case of fire, but it will prevent rats and mice from going up through the house from the cellar. At least it will check the spread of vermin, just as it will check the circulation of fire. By inserting stops on each partition cap and on the horizontal bridging between partitions, the entire house is divided into compartments, consequently should a fire start in the cellar or in one of the lower compartments, it will be checked temporarily by the brickwork and made to break out into a room, where in all probability it will be discovered before it reaches the story above.

SOUND-PROOFING WALLS

If any of the walls or partitions are to be made sound-proof, it is well to consider this work at the time they are covered in. No doubt you are well acquainted with the fact that ordinary partitions make excellent sound conductors, and under certain circumstances this feature is very bothersome. To overcome it special construction is necessary. If a wall is built with each side entirely separate, which really amounts to a double wall, the transmission of sound is wonderfully retarded. And if heavy paper or some other sound-deadening material, such as mineral wool, is inserted between the walls, the partition is made virtually sound-proof. A *quilting paper* or *sheathing quilt* is manufactured for this purpose.

In order to reduce the thickness of a sound-proof wall the studding is arranged alternately, as shown in Fig. 62. This is sometimes called a *staggered* partition. The *quilting paper* is shown woven between the studs.

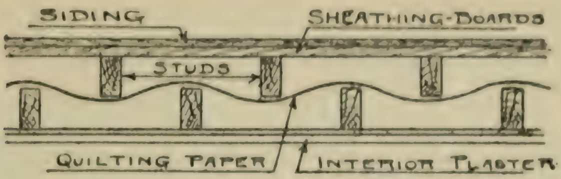


Fig. 62.—Sound-proof partition.

STUCCO OR EXTERIOR PLASTER

We have another item to consider under the head of frame walls; it is stucco, or exterior plastering. The use of stucco dates back to the ancients, though, of course, their material was little more than sun-baked clay. Modern stucco is a mixture of Portland cement and sand, with the addition of hydrated lime, which makes the plaster more impervious to moisture, and at the same time *fattens* the mortar, so that it will cover more surface and work easier under the trowel.

Properly applied, stucco is a durable wall covering; it makes the house warmer in winter and cooler in summer, and adds greatly to the fire-resisting qualities of the structure. Moreover, its maintenance charges are almost negligible. The difficulties encountered in applying stucco, and its occasional failure to remain in position, have created an unjust prejudice against it in the minds of some builders. The truth of the matter is, however, the troubles are almost always due to improper proportioning of the ingredients, delayed application of the plaster, or inadequate foundation or bond with the wall.

Stucco may be plastered over wood lath, wire mesh, or metal lath. The use of metal lath is continually increasing, and is to be recommended. It holds the plaster more firmly and is not so likely to sag or crack; it is almost impossible to detach stucco from metal lath even if soaked by water. Still another advantage lies in its fireproofness.

In preparing for a stucco-finished building the usual construction is completed as far as the exterior sheathing. Then, as in the preliminary work described for weather-boarding, the sheathing boards should be laid diagonally, so that no swaying or distorting will occur to crack the plaster. In good practice the sheathing boards are covered with building paper, which adds to the warmth, and over this are nailed wooden furring strips. Metal furring strips are made for this purpose, to which the metal lath or wire mesh is fastened by wires. Or metal lath can be had which incorporates the furring strip with the lath. It is called *self-furring* lath, and is laid directly on the sheathing.

Furring strips should be spaced about 12 inches apart. If wooden lath is used care should be taken to see that the laths are given the requisite number of nailings and are spaced properly—3/8 inch is the correct interstice. There is a tendency to nail them too close together, in which case sufficient mortar will not be pressed through the interstices to make a key. On the other hand, if the laths are spaced too far apart the wet mortar will not sustain its own weight.

Another point to remember: Wood lath should be thoroughly saturated with water before the plaster is applied, otherwise the dry wood will absorb too much moisture from the stucco and thus impair its strength. Some builders recommend painting wood lath with two coats of bitumen waterproof paint, to which plaster adheres. Metal lath should be painted, also, or coated with cement and water, so as to avoid rusting.

You were cautioned in an earlier chapter that the action of Portland cement is almost instantaneous, hence the stucco must be applied to its permanent position as quickly as possible after the water is added. No greater quantity of mortar should be mixed than may be used within an hour, preferably within a half-hour. If the mortar stiffens or takes on its initial set, no amount of retempering will preserve it; it is practically worthless. The proper proportions are 1 part cement to 2 parts sand, with one-tenth as much pulverized hydrated lime as there is cement—all measured by volume.

Do not guess at the quantities. They must be carefully measured or you will not get a uniform result. The mortar should contain enough water to form a dense mixture, free from voids, and of sufficient plasticity to spread freely under a trowel, and to afford a perfect bond with the wall.

For the first coat the addition of hair assists the plaster in gripping the meshes of the lath. Use a pound of good cow hair, or long cocoanut fiber well combed out, to every bag of cement. It is not necessary to use hair in the other coats.

All plastering should be begun at the top and worked downward, and run as continuously as possible, utilizing corners, windows, or other natural breaks for ending a day's work. The mortar must be forced well into the meshes of the lath; but do not trowel too much, or it will take on a smooth surface; just work it enough to force the plaster through the lath and bring it to the desired thickness. The first or scratch coat should be not less than $\frac{3}{8}$ inch thick, nor more than $\frac{1}{2}$ inch, and while it is still wet it should be thoroughly scratched or roughened with a saw-tooth paddle or other similar device, to form a tooth for the second coat.

As soon as the scratch coat has set sufficiently to support another coat, the finishing coat is applied $\frac{3}{8}$ inch thick. On three-coat work the intermediate and final coats need be only $\frac{3}{16}$ inch thick, and the intermediate coat should be scratched the same as the first.

Stucco is described in greater detail in the following chapter.

METAL LATH CONSTRUCTION

Another interesting method of construction is shown in Figs. 65 and 66. A specially manufactured metal lath, reinforced by rigid-ribbed members incorporated in the lath, is plastered on both sides with cement, and thus converted into a solid wall or partition. Neither studs nor forms are necessary; the sheets of metal lath are set up and braced temporarily, as indicated in Fig. 63, and after the plaster is applied and has had a chance to set, the wall is complete.

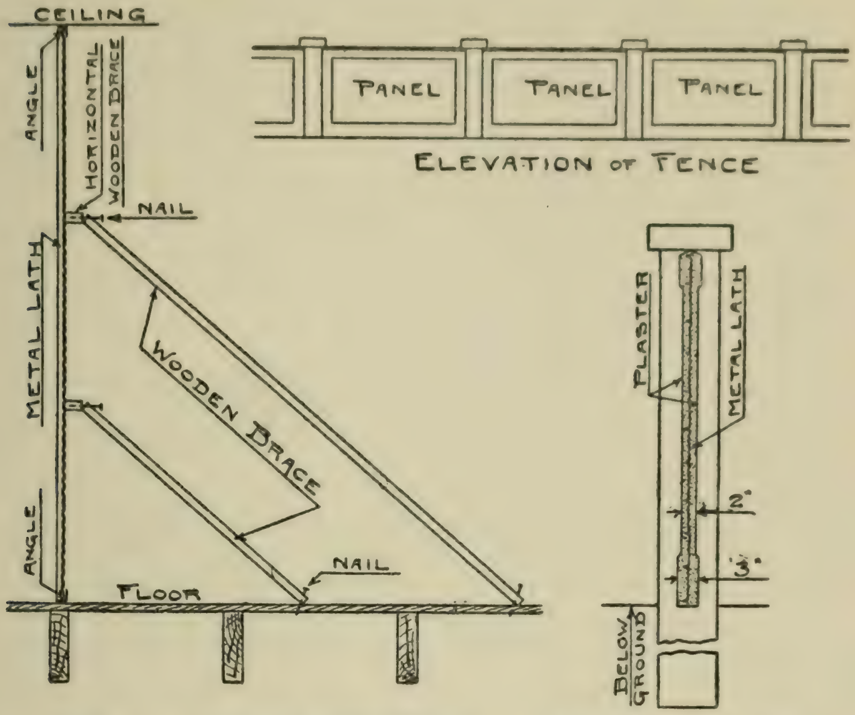


Fig. 63.—Metal lath temporarily braced ready for plaster.

Fig. 64.—Metal lath and plaster fence.

Construction of this kind has remarkable strength, and may be compared to reinforced concrete, for such it really is. It has been successfully used for curtain walls in factories, for partitions in fireproof buildings, and for fences. In the latter case it is supported by concrete posts, and built in the form of panels, as shown in Fig. 64. Where hollow walls are desired an additional layer of lath is employed, leaving an air space between the two faces (see Fig. 66).

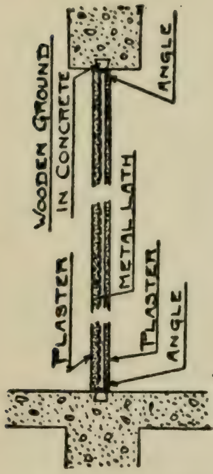
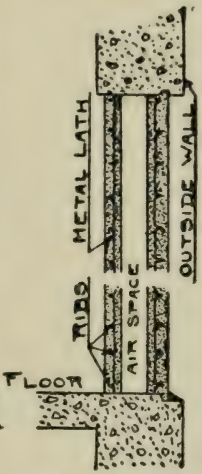


Fig. 65.—Single wall of lath and plaster.



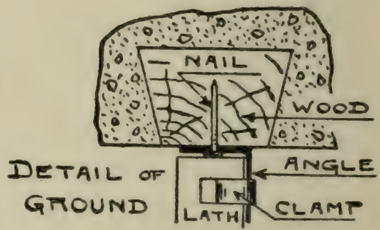


Fig. 66.—Double wall of lath and plaster.

Let us now review some of the other materials of which the inclosing walls of a building may be built, and which may be classified as masonry walls: The erection of hollow tile is so simple, and bears such a close similarity to brickwork generally—the chief difference being in the size of the units—that it will be considered as such, and as coming within the scope of the following specifications for good brick masonry.

RULES FOR BRICKWORK

No practical rule can be laid down for the thickness of brick walls; everything depends upon the height of the structure and the floor loads it is intended to carry. In large cities the least thickness of walls is fixed by law. Usually, exterior walls for two-story dwellings are made 8 inches thick, and for three-story houses 12 inches thick. Party walls are generally 12 inches thick. Bear in mind, too, that the length of a wall is a source of weakness, and that it should be increased about 4 inches for every 25 feet over 100 feet in length. High stories and clear spans exceeding 20 feet require thick walls, and walls containing openings to the extent of 33 per cent. of their area should be increased in thickness.

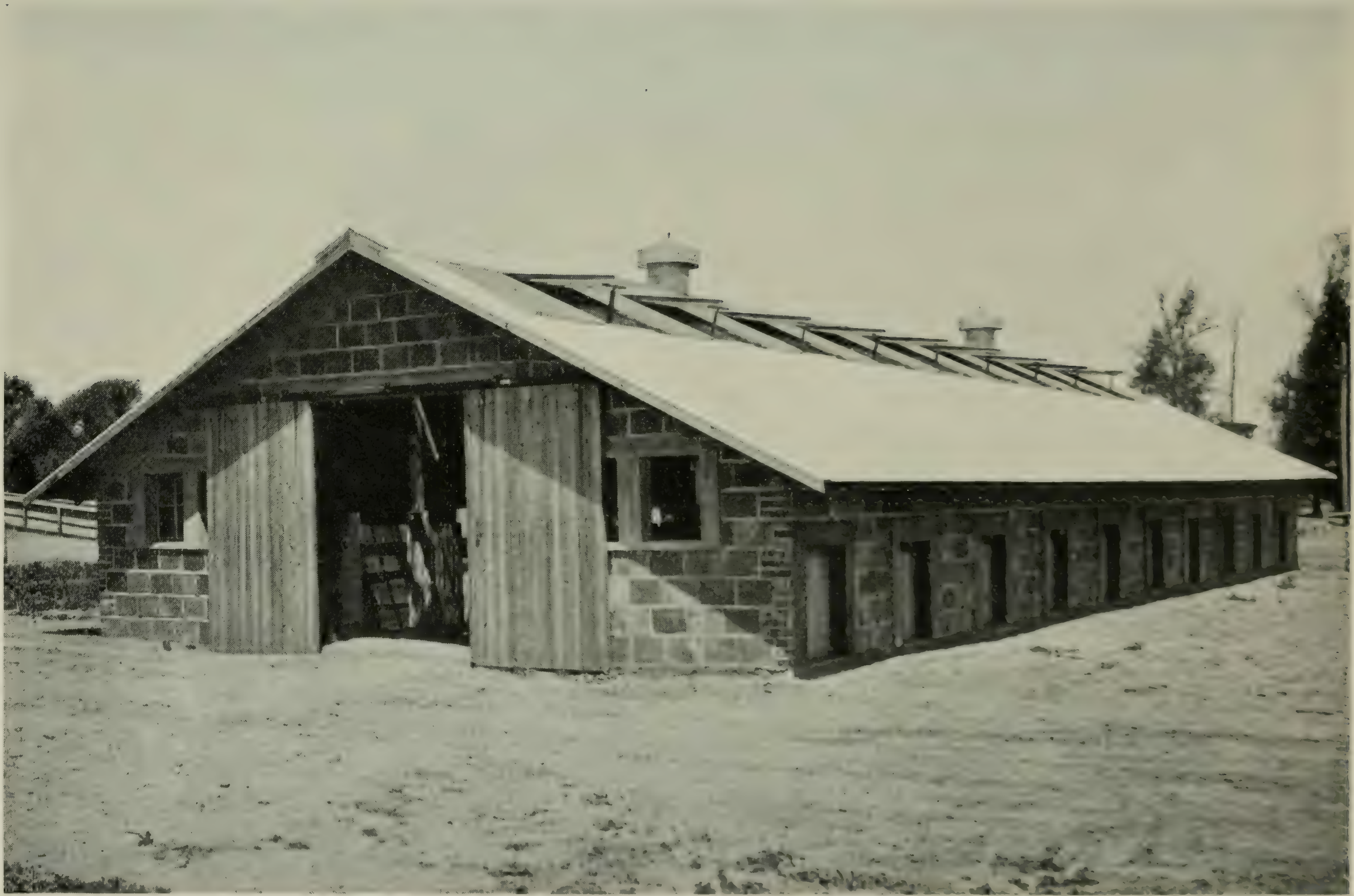
Brick masonry should be commenced on a firm foundation, and laid in a full bed of mortar, thoroughly filling the end and side joints with mortar at the same time. In fact, bricks should not be merely laid, but every one should be shoved or pressed into position, with a settling movement, in such a manner as to force the mortar into the pores of the bricks. This *trick* is simple enough with skilled bricklayers, but very often it requires close supervision to get it accomplished. Careless workmen have a habit of laying bricks in a bed of mortar, without *pressing* them and without *buttering* the edges, thereby leaving the vertical joints to take care of themselves. This creates voids and seriously weakens the work.

Each course should be laid as nearly perpendicular as possible to the direction of the pressure, and the bricks in each course should break joints with those in the course below. The thickness of the joints will vary from $\frac{1}{8}$ to $\frac{3}{4}$ inch, depending upon the nature of the work—whether the joint is to be concealed as much as possible or made a feature of the job. For ordinary work $\frac{3}{8}$ inch is the average width. Very thin joints or exceedingly thick ones require the most painstaking work, and should not be called for unless correspondingly increased cost is reckoned.

All misshapen and unsound bricks should be rejected. A good hard brick will ring when struck by a trowel. In good practice bricks are wetted to the point of saturation before being laid in the wall. They have a great avidity for water, especially soft bricks, consequently if they are not previously saturated they will absorb too much water from the mortar and cause it to crumble.

Common bricks are those which have no special care taken in their manufacture; they are rough and unpressed, and adopt a quality according to the position in the kiln in which they are burnt. Face bricks, or hard bricks, include various kinds of molded bricks, and are actually shaped and pressed by machinery. They are more expensive, of course.

It is often desirable to give a frame structure the appearance of brick without making the building de-



Hollow tile hog house with skylight roof

pend upon this material for its strength. This construction is called brick veneer. It adds to the warmth of the structure, to its durability, and to its fire-resisting quality. The walls are built with a frame of studs, covered with sheathing boards, the same as for weatherboarding, and then veneered on the outside with one thickness of bricks, as shown in Fig. 67. The veneering is tied to the frame by means of metal ties, A, which should be carefully fitted at fairly close intervals.

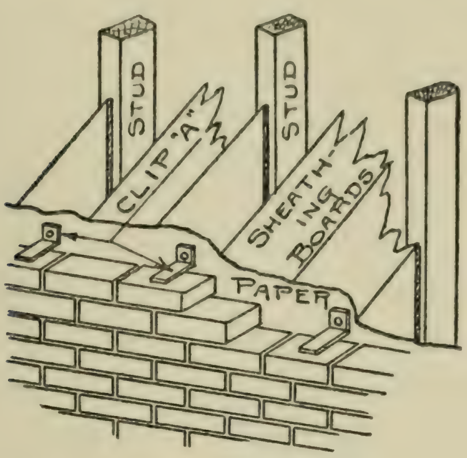


Fig. 67.—Brick veneer.

Stone masonry and concrete, two other materials frequently used in the construction of inclosing walls, will receive no particular explanation in these paragraphs. Both topics were discussed at length in preceding chapters under the subject of Foundation Walls. The same general requirements obtain above ground, except that the workmanship should be neater, perhaps, and conform to some particular architectural scheme.

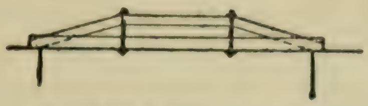
Appearances count for a great deal, even in the matter of a barn; make no mistake about this.

STEEL CONSTRUCTION

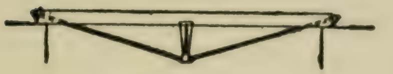
The one other material for us to consider is steel. We find entire barns and numerous other buildings made of this material; the frame usually consists of angle bars, channels, and I-beams covered with corrugated galvanized sheet iron, or specially rolled metal. Such structures are reasonable in cost, comparatively simple to erect, and have among other merits durability, low maintenance charges, and a non-combustible nature. True, steel is hotter or colder at times than other materials, but these disadvantages, if they are such, can be overcome or modified to a great extent by ventilation or insulation. For some purposes the question of added heat or cold is not objectionable anyhow, or it is compensated by the increased fire protection of an all-steel building. Some manufacturers guarantee these products to be rust-proof; a careful study of their literature will prove interesting.

TRUSSED GIRDERS

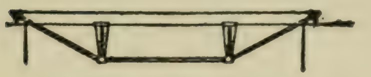
For small dwellings and the general run of frame buildings there will be no difficulty in securing timbers large enough for every purpose. But, if a very long span is to be made, or an unusually heavy load must be carried, it is often impossible or impracticable to get a single timber strong enough to do the work. It then becomes necessary to either employ a steel beam or column, or to truss a wooden girder. Steel beams are now commonly used, and have supplanted the wooden girder as a general practice. While they are somewhat expensive so far as material is concerned, they represent a considerable saving in labor over the trussed girder, of which Fig. 68 may be said to be typical.



Trussing above the beam.



King post truss.

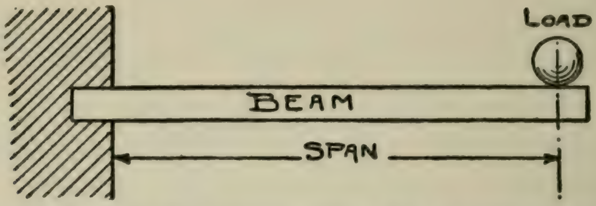


Queen post truss.

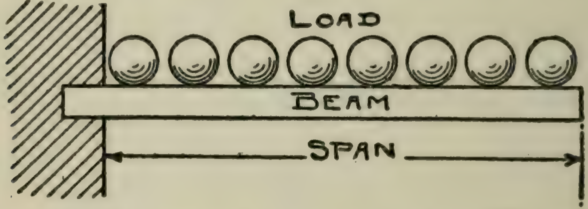
Fig. 68.—Trussed wooden girders.

LOADS ON BEAMS

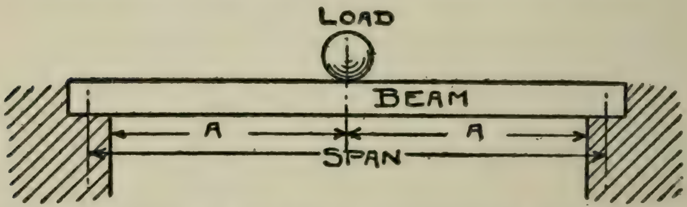
The first step in determining the size of a beam or column is to calculate the exact amount of load to be carried and its distribution. Loads may be uniformly distributed or concentrated, or both, as illustrated in Figs. 69 and 70. Furthermore, the total load is influenced by two factors—the dead load, the fixed weight of the construction, and the live load, the superimposed load, which is likely to be variable. These calculations involve engineering formulae which had better be studied from a text-book.



Beam fixed at one end, concentrated load at unsupported end.



Beam fixed at one end, uniform distribution of load.



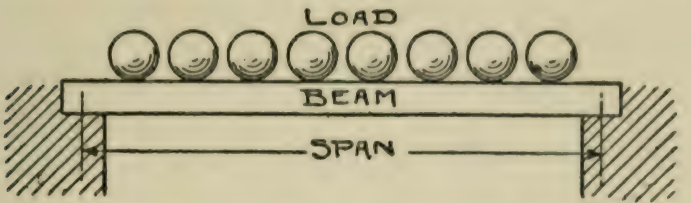
Beam supported at both ends, concentrated load in center.

Fig. 69.—Diagrams of loads on beams.

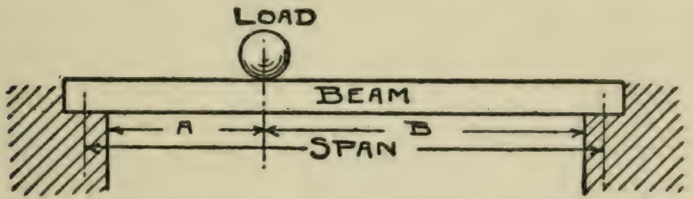
STEEL COLUMNS AND BEAMS

Columns and beams may be made of any of the standard structural shapes—channels, I-bars, angles, tees and zees, or any combination of them. Figure 71 illustrates sectional views of the most common types. In most cases the virtues of these combinations will be evident from an inspection of the figures. Note the white spaces between the black lines indicating the different shapes do not represent actual spaces; this is simply a conventional method showing the relation of the various units.

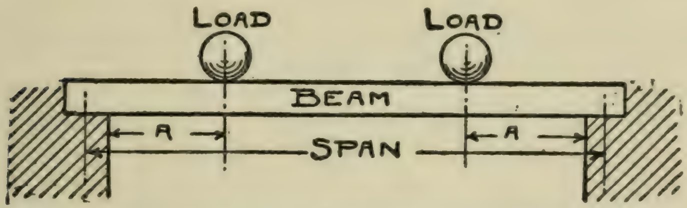
No definite rule can be given for the use of any particular section to the exclusion of others. Each shape or combination has its advantages, and must be selected according to the work it is intended to perform, and the conditions under which the work is imposed.



Beam supported at both ends, uniform distribution of load.



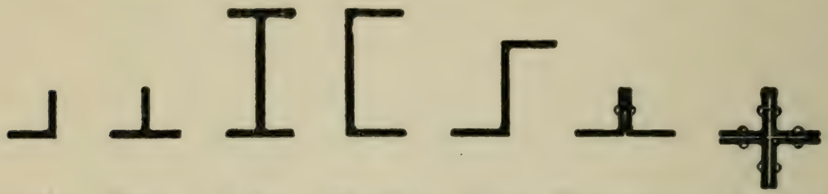
Beam supported at both ends, concentrated unsymmetrical load.



Beam supported at both ends, two symmetrical loads.

Fig. 70.—Diagrams of loads on beams.

Plain angles, channels, and I-bars are the most readily adaptable shapes for all-round purposes. They make convenient lintels for door and window openings; strong girders, to which it is easy to secure bearing for wooden floor beams; and satisfactory columns for the support of heavy loads. Iron pipe is often used for columns, a cap and base being cast or screwed to the ends. Sometimes the pipe is filled with cement, which gives such a column remarkable strength.



Angle. Tee. I-bar. Channel. Z-bar. Two angles. Four angles.

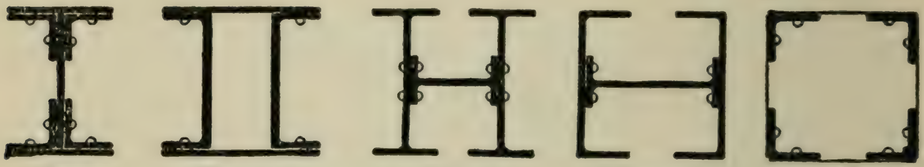


Plate girder. Channel girder. I-bar column. Channel column. Fabricated angle column.

Fig. 71.—Common types of steel shapes.

CHAPTER VII

SUGGESTIONS FOR THE USE OF STUCCO

THE use of stucco dates back to our earliest knowledge of man, when crude huts were built of rough-hewn timbers or thatched reeds, and then chinked or plastered with mud that baked hard in the sun and thus made the house warm and a shelter against storms. Later the Greeks and Romans used a mud stucco to plaster over sun-burned bricks and rough masonry, and some of the finest examples of their early art—exquisite frescoes and mosaics—are still preserved in a stucco matrix. Here in America our oldest structures, the cathedrals of Mexico, erected by the Spanish in the 16th century, and the historic old Missions of the Southwest, priceless landmarks of our pioneer days—have stuccoed exteriors and interiors, and to this day they remain as staunch as ever and in a comparatively perfect state of preservation.

These relics, however, were confined to dry, warm climates, without frost action or excessive moisture to disintegrate the poor material then available, and could not have endured the severe winters of a Northern climate. Yet they furnished the motive for experiments with other materials that have since established stucco as a principal building medium. The use of lime plaster replaced the original mud stucco, and proved better able to resist the ravages of frost; until today, with the development of Portland cement stucco, we have a material that will permanently endure any climate and under the most adversely varying conditions. It is especially valuable for renovating old buildings, and may be used successfully and economically where, perhaps, no other material would answer the purpose. Farm houses, for example, lend themselves admirably to a stucco treatment, and many otherwise ramshackle buildings have been transformed into charming bits of architectural beauty by this simple expedient.

ESSENTIALS TO SUCCESS

The difficulties encountered in applying stucco and its failure to remain in position have, perhaps, created an unjust prejudice against it in the minds of many; when, in reality, the trouble is almost always due to improper proportioning of the ingredients, a delayed application, or an inadequate foundation or bond with the wall. The following ten commandments are the essentials to success with stucco; they are common-sense reasons, and if carefully observed, no trouble or disappointment will be experienced:

I. Use a good grade of cement; a poor quality is like any other inferior article—it is false economy.

II. Use only clean, sharp sand; or, if the aggregate is to consist of crushed stone or marble chips, the grains should pass through an 1/8-inch screen, and be free from loam, vegetable, or other deleterious matter. Material of a silicious nature is preferable. The proportion of sand to cement should not be less than 2 to 1 by volume, nor exceed 2½ to 1.

III. There should be 1 part lime to every 10 parts of cement, and it must be thoroughly hydrated. If this is done at the operation, it must be slaked without burning, using sufficient water to form a paste or putty, and allowed to stand a week before using.

IV. Water must be clean, pure, and free from oil, acid, or strong alkali.

V. Where hair or fiber is employed in the first coat, use only finest quality cattle hair or a long cocoanut fiber well combed out—1 pound to every bag of cement.

VI. If coloring matter is used, it should be a mineral substance; or, if artificial, then of known reliability, a material that will not be affected by the action of lime or cement.

VII. All ingredients should be carefully measured by volume for each batch and thoroughly mixed; otherwise a uniform, homogeneous texture and appearance will not result. The mortar should contain enough water to form a dense mixture, free from voids, and of sufficient plasticity to afford facility in troweling, and a perfect bond with the foundation wall.

VIII. The action of Portland cement is almost instantaneous, hence the stucco must be applied to its permanent position as quickly as possible after the water is added. No greater quantity should be mixed than may be applied within an hour; and if the mortar stiffens or takes on its initial set, no amount of reworking or retempering will preserve it.

IX. The foundation or wall offered to receive the stucco must be absolutely rigid, scrupulously clean of any oily or vegetable matter, and of ample roughness or construction to assure a strong bond between the mortar and the surface of the building. If applied to wood or metal lath, it should be well pushed through the interstices so as to form an adequate key. The first, or scratch coat, should be $\frac{3}{8}$-inch thick, thoroughly roughened with a saw-tooth paddle or other suitable device while the mortar is still wet; as soon as it has set sufficiently to support another coat, the finishing coat is applied $\frac{3}{8}$-inch thick. If three coats are employed, then the intermediate and final coats need only be $\frac{3}{16}$-inch thick each, and the intermediate coat is scratched the same as the first.

X. The final coat should not be permitted to dry out too rapidly, or in advance of the foundation coat, and should be retarded if necessary by sprinkling or hanging wet burlap against the surface. Stucco should never be applied in a freezing temperature, nor where there is likelihood of settlement to the building.

HYDRATED LIME

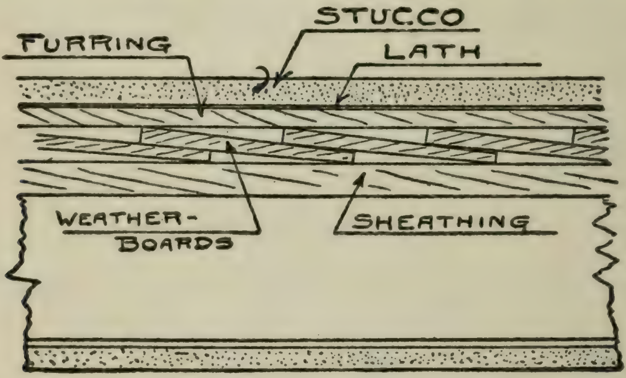
Hydrated lime may be purchased in convenient packages in powder form from the manufacturers, and there is then no danger of unslaked lime entering the stucco. Hydrated lime never air slakes; it is lump lime slaked with water by a mechanical process and the moisture driven off, leaving it in the form of a fine, dry powder. It should be mixed dry with the cement —1 part lime to 10 parts cement. When ready for use, add 2 parts dry sand to 1 part lime-cement mixture; turn and rake until the mixture has a uniform appearance, when it may be used as required by adding sufficient water.

If lime putty or paste is used, good, double-strength lime should be slaked in plenty of water, and stirred only slightly to prevent the large lumps from burning. For this purpose it is convenient to use a box raised from the ground, and fitted with a sluice and screen at one end so that the slaked lime may run off into the sand crater—a pile of sand hollowed out in the center to form a basin—where it is later mixed with the sand in the proportion of 1 part lime to about 9 parts sand. In this method the cement is mixed dry with an equal volume of sand, and this dry mixture is worked into the lime-sand paste in the proportion of 1 part lime-sand to 2 parts cement-sand—adding water when necessary.

Lime makes the stucco more impervious to moisture, and renders a smooth consistence to the mortar, which would otherwise work stiffly under the trowel. To insure absolute waterproofness, however, the stucco should be mixed with the water containing 10 per cent. of a waterproofing solution, which may be purchased in either paste or powder form and is designed to render the mortar non-porous.

STUCCO ON FRAME STRUCTURES

There are several methods of construction for applying stucco to frame buildings, but the practice most generally used is shown in Fig. 72. The sheathing boards should be laid diagonally across the wall studs,



Stucco over weather boards.

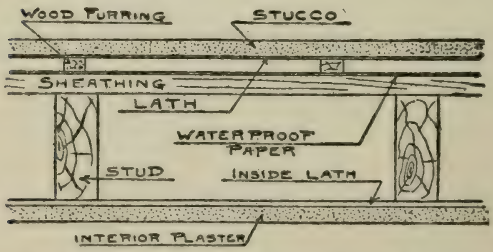


Fig. 72.—Stucco over sheathing boards.

and securely nailed to each stud so that no swaying will occur to crack the plaster. Over the sheathing boards a substantial grade of tar paper, or felt paper thoroughly saturated with tar or asphalt, should be laid in horizontal courses, beginning at the bottom and with each succeeding course overlapping the lower one by 2 inches.

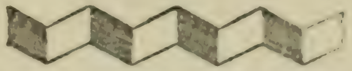


Fig. 73.—Metal furring strips.

All roof gutters, rain conductor hangers, flashings, and the trim to all doors and windows, etc., should be in place before the plastering is started. Either wooden furring strips or metal furring—crimped band iron, galvanized or painted, as shown in Fig. 73—should be nailed over the waterproofing paper, 9 to 12 inches on centers, or directly over the line of the studs. The former is used for wood lath; whereas, for metal lath, wire mesh, or expanded metal the metal furring is more satisfactory; and to this the lath is securely wired.

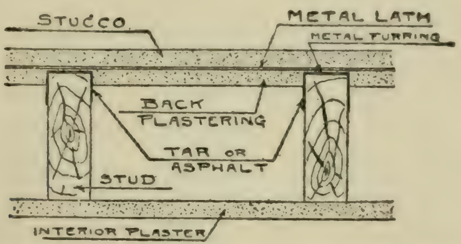


Fig. 74.—Stucco without sheathing boards.

Figure 74 illustrates another method of applying stucco, without sheathing boards, where the metal lath is laid directly on the wall studs, which have first been given a coat of tar or asphalt. In this method the interior surface of the lathing is back-plastered with stucco after the scratch coat has been put on the outside, and should increase the thickness of mortar inside the lath to about ½ inch.

It is quite evident that stucco may be applied in a similar manner to old frame structures that were originally weather-boarded or shingled; in this case it is necessary to carry out the door and window trim unless the stucco is to remain flush with it. Or the trim may be removed entirely and the stucco brought around the casing, thus affording the appearance of a recessed window with no wood showing. If the weather boards or shingles are badly rotted away and offer an insecure ground for nailing the furring strips and metal lath, it is advisable to remove them altogether and commence as for a new house.

STUCCO ON BRICK AND STONE

Nothing is harder to renovate than the exterior of a badly weathered brick building, unless stucco is used, which may be applied directly to the brick surface; or to metal lath secured to the bricks by wooden plugs driven into the mortar joints. If applied directly on the bricks, the old mortar joints should be raked out for at least ¾ inch, see Fig. 75, and the entire surface scrubbed with a 10 per cent. solution of commercial hydrochloric (muriatic) acid, great care being taken that all traces of the acid are thoroughly rinsed off before the stucco is applied. The first coat of plaster is thoroughly forced into the old mortar crevices, and forms an excellent bond; and on account of the extremely porous nature of brick the wall should be first saturated with water. If not, the brickwork will absorb too much water from the plaster and thus impair its adhesion. All plastering should be commenced at the top and worked downward, and run as continuously as possible, utilizing corners, windows, or other natural breaks for ending a day's work.

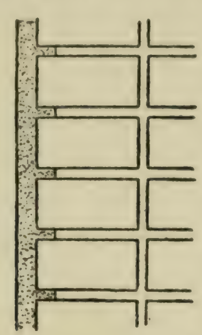


Fig. 75.—Stucco on brick.

Stone exteriors are renovated much the same as brickwork: first pick out the old mortar, clean the surface thoroughly with acid, and then saturate it with water; or, if the surface of the stone work is particularly rugged and angular, and presents a good *tooth* for the plaster, it may not be necessary to remove the old mortar, except the loose pieces. To repair an old stone wall that has been porridged with lime mortar and afterward whitewashed, be careful to remove all dirt and fine particles of sand, cleanse with acid, and then build out to the old plaster line with one or more thin coats of stucco. It is most impracticable to attempt to trowel mortar thicker than $\frac{3}{8}$ inch on the side of a vertical wall; it will only sag with its own weight and fall off.

Figure 76 illustrates the method of applying stucco to terra-cotta hollow tile, which is scored and dove-tailed for the purpose, and is, without question, the best foundation for stucco.

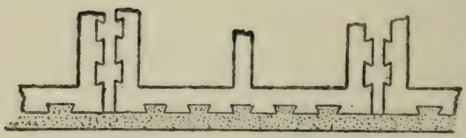


Fig. 76.—Stucco over hollow tile.

FINISHING THE SURFACE

The architectural possibilities of stucco are unlimited and offer a wide range for ingenuity. The surface may be treated in various ways, and in addition to this the stucco may be colored and made to harmonize with a general scheme; or it may be judiciously inlaid with a few ornamental tiles and thus given rare individuality and character. The following treatments are those most commonly used, and may be readily followed with a little practice:

Smooth Troweled.—The surface may be brought to a flat, smooth appearance by using a metal trowel—with long, sweeping motions, not rotary ones.

Stippled.—After the final coat has been brought to a smooth surface, it may be patted lightly and evenly with the ends of a coarse brush or broom to give the desired effect.

Rough Cast.—A coarse-grained texture is obtained by using trowels covered with burlap or carpet, and to aid the effect the sand in the stucco should be coarse and the mortar not too wet.

Pebble Dash.—As the name implies, clean pebbles, not exceeding $\frac{1}{2}$ inch in diameter, are thrown against the final coat when it is fairly wet. The pebbles should be wet also and thrown with a broadcast motion, using sufficient force to embed them securely.

Exposed Aggregates.—The finishing coat may contain crushed stone, marble chips, or limestone, and after it has set for about twenty-four hours the surface is scrubbed, uniformly, with a stiff brush and water, which removes the outer cement film and exposes the true color of the aggregate.

So many pleasing shades and effects are obtainable by natural means that the use of artificial coloring should be given careful consideration as to permanence and probable deterioration of the cement. It is safer to use only mineral pigments, those of known reliability, and after carefully experimenting for the desired shade. They may be mixed dry with the cement or stirred into the water, and very precise measurements are required to produce a uniform result. Ultramarine blue, red oxide of iron, yellow ochre, and carbon black are the principal commercial colors, and cost from 10 to 20 cents per pound. About 5 pounds of color are required for every bag of cement.

CHAPTER VIII

ROOF—ITS SHAPE, FRAMEWORK, AND COVERING

SINCE the beginning of history there have been writers and philosophers who have cautioned us to build upon strong foundations. This is excellent advice, to be sure, but somehow I have often felt that it was rather partial—or incomplete. It is a question in my mind if the roof is not equally as important as the foundation, perhaps more so.

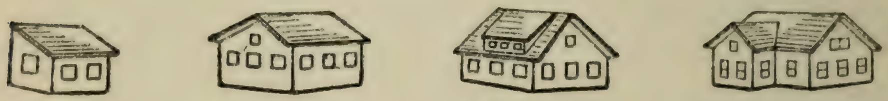
After all is it not the roof which must withstand the real battle against the elements—heat, cold, wind, sleet, snow, and rain? Surely, there can be no sense of security in a building if its roof is infirm. And is it not woeful lack of foresight to expend large sums on the structural and interior portions of a barn or dwelling, together with their furnishings and contents, and then leave them to the mercy of a questionable roof?

The roof is the covering of the building, and its integrity, like the strength of the foundation walls, should be absolutely trustworthy—reliable. The roof, in fact, bears the same relation to the rest of the structure that the keystone does to the arch-ring of stones. Remove the keystone or impair its strength and the arch collapses.

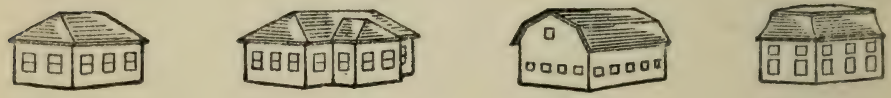
Not alone from the standpoint of service, but also in appearance the roof is the dominating feature of a building. Architecturally, it will either make or mar the entire structure.

SHAPES OF ROOFS

Without entering into the details and technicalities of the various conditions which may impel certain shapes and styles of roofs, let us review a few of the simplest forms, the framework required, and the adaptability of different kinds of roofing materials.



Shed roof. Gable roof. Combination gable roof. Gable-and-valley roof.



Hip roof. Hip-and-valley roof. Gambrel roof. Mansard roof.

Fig. 77.—Conventional types of roofs.

In Fig. 77 there are shown outlines of some conventional varieties: First, the *lean-to*, or ordinary *shed roof*, consisting of one rectangular *plane* or *slope*, which is the simplest method of construction. It is employed for small *sheds*, *piazzas*, *ells*, and similar situations, usually in the cheaper class of buildings.

The *pitch* or *gable roof*, sometimes called the *saddle roof*, is the most commonly used. It admits of a wide variety of effects, and may be used in combination with roofs of other kinds. It has two *slopes* or *planes*, meeting at the center or *ridge*, and forming a *gable* at each end of the building. The *slopes* may be of equal or unequal size, of steep *pitch* such as are found in many of our colonial houses, or of the low wide-spreading type which is characteristic of bungalows. The monotony of a large, otherwise regular *plane* can be relieved by a second *plane* projecting from the main roof like a *dormer* and terminating in a continuation of the side wall; or a *gable-and-valley roof* may be formed by joining at right angles two simple *gables*.

A *hip roof* consists of four *slopes*, rising from all four walls and terminating in a *ridge* or *point*, like a pyramid. This arrangement insures a low spreading roof and is therefore economical, but it is sometimes rather severe looking. It may be broken by a flat *deck*, or by the juncture of an *ell*, which creates a *hip-and-valley roof*, in contradistinction with a *gable-and-valley roof*.

The *gambrel roof* resembles the *gable roof*, except that each side of the former is made up of two *planes* or *slopes* of different *pitch*. It is a development of the *gable roof*, and has long been very popular, probably because of its obvious utility. In dwellings it permits full use of the up-stairs space without the expense of an attic; and in barns it furnishes the greatest amount of accessible mow space, especially in the modern designs which are self-supporting. It also materially reduces the area of the side walls, which is a worthy factor in some instances.

The *mansard roof*, named after the architect who introduced it, is a modification of the *hip roof*. In reality it is little more than a *hip roof* of extreme *pitch*, with the *planes* almost vertical, surmounted by a flat *deck* on top. The *planes* may be straight, concave, or convex, as desired.

The *flat roof*, so much in vogue in cities, need hardly be described. It is purely a utility roof, made necessary where houses or factories are built in solid rows where there is no room for *gables*, *eaves*, and *angles*. The severity of a *flat roof* is usually broken by an ornamental *cornice*.

FRAMEWORK OR RAFTERS

In all roofs the timbers which go to make up the framework are the *rafters*. They bear the same relation to the roof that joists do to the floor, or studs do to the wall. There are four principal kinds or, let us say, classes of rafters, all of which are in general use. Note Fig. 78, which is a typical roof-framing diagram. The timbers marked A, A, A are known as common rafters; they extend from the plate, which is the timber secured to the tops of the studs, clear to the ridge, without any support from the other rafters. The members designated as B, B, B are jack rafters; they are shorter than the common rafters, of varying lengths, and do not extend from the plate to the ridge, but are secured at one end to a valley or hip rafter.

Those portions of the roof formed by the intersection of an ell, at the points where the roof planes or surfaces come together, are aptly called *valleys*, hence the term *valley roof*. In the hip roof, where the planes oppose each other pyramid fashion, and form outside corners, these sloping ridges or corners are termed *hips*. Therefore the timbers needed at the corners C, C are called *valley rafters*, and those framed at the ridges D, D are known as *hip rafters*, which complete the four divisions previously mentioned.

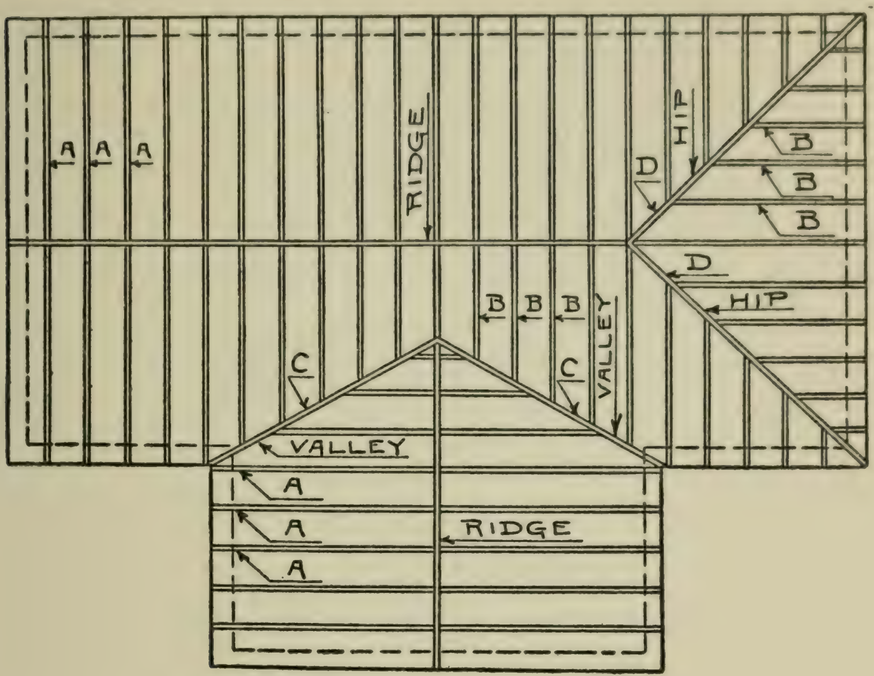


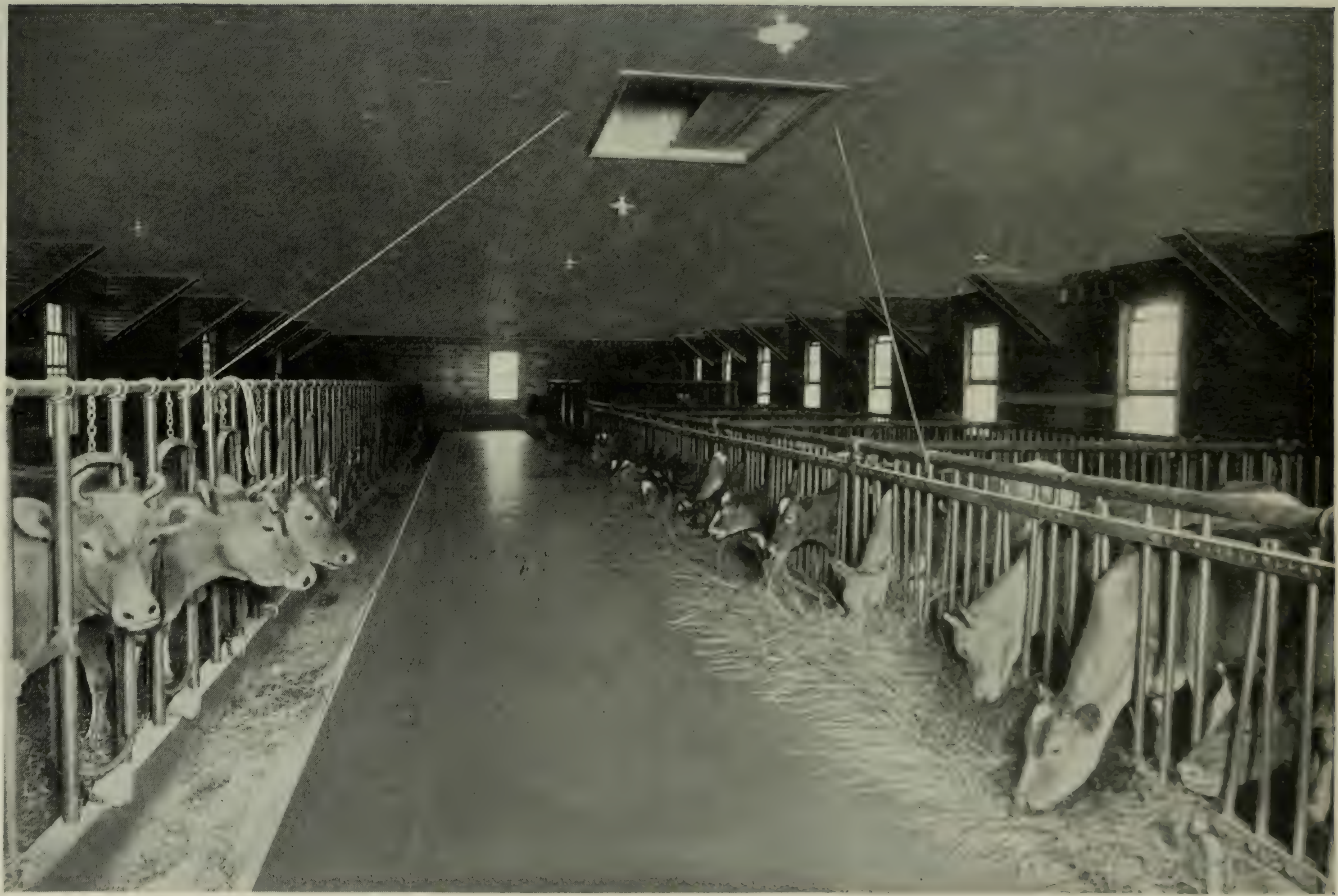
Fig. 78.—Typical roof-framing diagram.

In dwellings and similar structures the rafters are usually spaced from 16 to 20 inches on centers, and are fastened to the frame in various ways, depending upon the form of the roof. In barns the spacing is frequently increased to 24 inches, in which case the size of the rafters is increased proportionately. For ordinary purposes 2 x 6-inch material is sufficient. If the span is long, or the roof must carry exceptionally heavy roof covering like slate or tile, or if the structure may be called upon to withstand a heavy snow load or to resist high wind pressure, it will be necessary to use 2 x 8-inch or even 2 x 10-inch timbers.

Rafters are seldom framed into the plate, that is, the plate is not cut out in any way to receive them. Instead, the rafters are spiked to the plate; and to counteract any outward thrust the rafters are tied in some way, which will be described in a succeeding paragraph. Usually the rafters are made to extend beyond the wall so as to form the eaves, in which case they are notched at the correct bevel to take sufficient bearing on the plate.

LOOKOUT RAFTERS

Sometimes it will be found more economical to stop the rafters at the plate, and to form the eaves by nailing short pieces to the rafters, such pieces being called *lookouts*. These do not always continue in the same line as the rafters, but may make an angle with it, as shown in Fig. 79. This practice is generally resorted



Interior of a well-designed dairy barn

to on gambrel roof barns, where it is not practicable to permit the rafters to form the eaves.

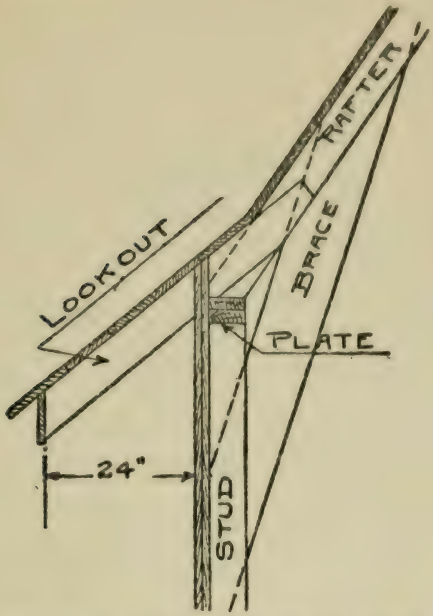


Fig. 79.—Lookout rafters for eaves.

In the lean-to or shed roof both ends of the rafters rest on a plate, or they are spiked at one end to the wall

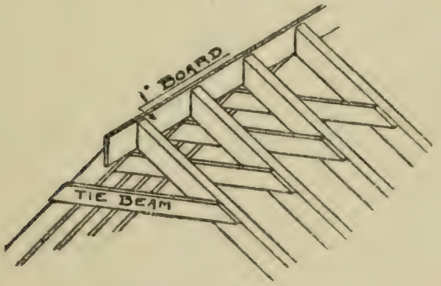


Fig. 80.—Ridge pole and tie beam.

which the ell or piazza adjoins. In the gable roof, in fact, in all other types of roofs the principle is followed that if two timbers are inclined against each other they will hold each other up, consequently the rafters are set up in pairs, thrusting against each other at the top or ridge. To insure a straight line at this point, and to keep the rafters in place until the roof boarding is put on, it is customary to employ a ridge pole, as shown in Fig. 80. This pole may be a 1 x 8-inch board, or any stuff that is convenient to use, and it may be kept flush with the ends of the rafters, or allowed to extend above them, with the view to forming a center for some kind of a metal cresting for the ridge, as shown in Fig. 81.

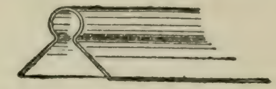


Fig. 81.—Metal cresting for ridge.

COLLAR BEAMS OR TIE BEAMS

In roofs of short span, where the rafters are not long enough to sag, there is no necessity for interior support other than tie beams, sometimes called collar beams. If, however, the rafters are necessarily long, for example, if they exceed 12 feet, it will be imperative, perhaps, to support them in some way. This can be accomplished by erecting a piece of studding under each rafter, or by using fewer uprights and substituting slightly heavier studs which carry a horizontal timber or purlin the entire length of the building, which purlin supports all the rafters, as shown in Fig. 82.

In dwellings where there is to be a finished attic upstairs it is better to use a light stud under each rafter, for these studs are then made to form the side walls of the attic rooms, and would have to be spaced on about 16-inch centers anyhow.

If the tie beams, which are usually 1-inch boards 8 or 10 inches wide, are kept as near the center of the rafter as may be practicable, they will tend to keep the rafters from buckling inward in the middle, or "kicking" outward at the plate, and will greatly stiffen the entire construction. These tie beams are also used as a support for the attic ceiling and their height should be determined accordingly.

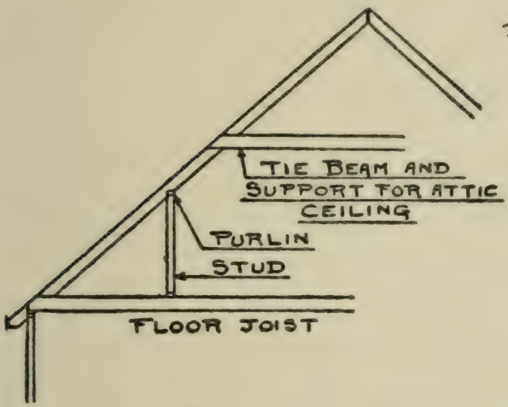


Fig. 82.—Stud to support long rafter.

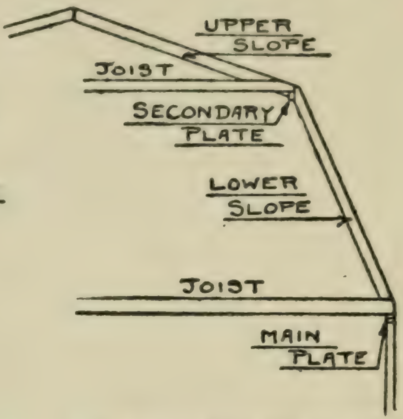


Fig. 83.—Framing for gambrel roof.

The gambrel roof of a dwelling is framed in much the same way as the common gable roof, except the slope being broken at a point about midway between the plate and the ridge, at which point the pitch of the lower and upper planes changes, there is need for two distinct sets of rafters. The feet of the lower rafters take bearing on the main plate, and at the point where the slope changes there is a secondary plate or purlin, from which the upper rafters start and run to the ridge (see Fig. 83).

The rafters of the lower slope, which might be reckoned as a part of the side wall, are notched at the top to form a seat for the secondary plate. They are securely spiked to the main plate, and for additional security it is a good plan to spike the floor joists to these rafters, so as to act like tie beams. The rafters forming the upper slope are notched to seat over the secondary plate or purlin, and spiked to it. This secondary plate is used as a support for the ceiling joists, which are likewise spiked to the upper rafters, and thereby act as tie beams. Thus the entire framework is tied together, and the workmanship being properly executed, there is formed a very rigid structure.

PROPORTION OF A GAMBREL ROOF

Figure 84 illustrates a simple method of determining the proportion and general shape of a gambrel roof. Remember, it is the relation of the two slopes and their pitch which gives this style of roof its real character. Draw a semicircle, using a radius equal to one-half of the width of the building. With the points A–B–C bisect the arc at D; then with any convenient height (E), which will approximate the ceiling height in the upper floor, draw a line F–G parallel to A–B, and the points A, F, D, G, B will outline the general contour of the roof. The proportions may be varied by changing the height at E.

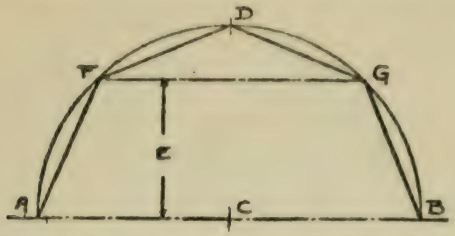
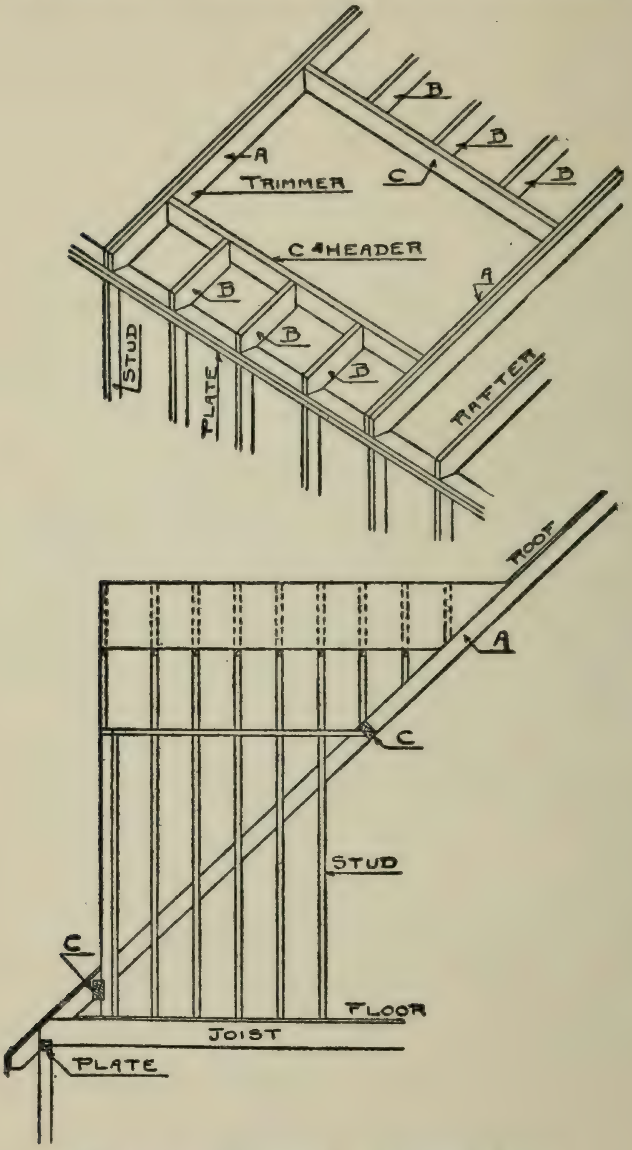


Fig. 84.—Diagram for determing proportions of a gambrel roof.

DORMER WINDOW FRAME

To construct a dormer window, or if a chimney passes through the roof, special framing is necessary to take care of the break in the continuity of the rafters, see Figs. 85, 86. The rafters A, A forming the sides of the opening are called trimmers, and must be strong enough to carry the load of the intervening rafters B, B, B together with the weight of the dormer. It is customary to double the ordinary rafters for this purpose. Between the trimmers are fitted the timbers C, C, which are called headers, and these receive the ends of the rafters B, B which are cut by the opening. The remainder of the dormer is framed in much the same way as an ordinary wall and simple gable roof. Other openings—for skylights, ventilators, trap-doors and such like—are framed similar to the openings for dormers. See Fig. 87.

The method of boarding the roof—that is, covering the rafters preparatory to putting on the actual roofing material—depends mainly on the sort of material contemplated. If shingles are to be used the rafters can



Figs. 85, 86.—Framing for dormer window.

be *shingle-lathed*, which consists in covering the rafters with 1 x 2-inch battens spaced on about 6-inch centers, to act as nailing grounds for the shingles.

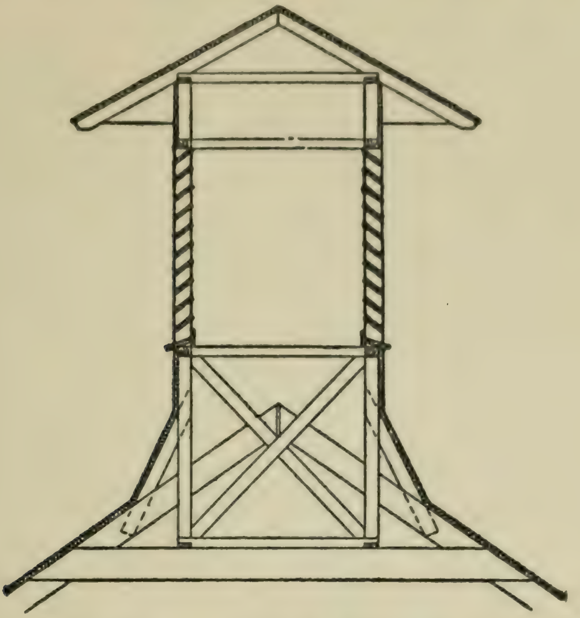


Fig. 87.—Framing for cupola.

Slates and tiles are sometimes laid on battens, too, but it is not considered good practice.

ROOF COVERINGS

Tin roof, copper, in fact, all kinds of metal and composition roofings require a solid board roof, and it is best to provide the same for tile and slate roofs. The boards may consist of plain, undressed lumber, though it is advisable to use matched boards. They make a tighter roof, and should warping occur they are not so likely to damage the roof covering.

For the covering a variety of materials may be used, among which are wooden shingles, asbestos shingles, tin, copper, slate, tile, galvanized iron, tar and gravel, composition shingles, besides many patented preparations in sheet and roll form, popularly known as "ready to lay" roofings. To select the variety best suited to a given purpose is frequently a problem, and one that the average builder must solve for himself. The man of unlimited means has more avenues of escape from this perplexity than the fellow with a slender pocketbook, who is sometimes obliged to accept what he would prefer not to have for reasons of economy.

We might say, and justly so, that all roofing materials have their advantages and disadvantages. For example, a copper roof is about the last word in permanence, but its cost is so high as to be prohibitive on moderate priced structures. Conversely, a tar-paper roof is reasonable in cost, but it is not particularly good looking, neither is it so durable. Spanish tile makes an attractive roof, but, like copper, its cost is beyond the reach of the average farm builder. Then, too, massive construction is necessary to support it. A slate roof is durable, good looking, and among other virtues it is fireproof, but it is impossible to use slate except on roofs of comparatively steep pitch. Contrariwise, a tar and gravel roof is durable, economical, fire-resisting, and thoroughly practicable on some buildings, but it cannot be used on steep roofs. It must have a flat roof, so that in warm weather when the tar softens these waterproof membranes will not run from the roof.

Wooden shingles lend character to a roof, and they are fairly reasonable in cost; they are also adaptable to many styles of buildings; but the objections raised against them are inflammability and the fact that they deteriorate rapidly unless used on roofs of steep pitch, or where the roofs are frequently gone over and painted. Corrugated sheet iron has fireproofness and other qualities to commend its use, but, on the other hand, sheet metal is likely to be cold or hot unless insulated, and it is very apt to give the building a factory look.

In view of these conditions, other materials were considered for roofing purposes—materials that would embody as many virtues as possible and at the same time eliminate the disadvantages. In consequence, "prepared roofings" have come into prominence. The reliable brands offer liberal guarantees and should be investigated. It is amazing the uses and the wear to which some of these roofings have been subjected. They are in no sense a temporary roofing, as many persons might suppose, but a permanent, effective, waterproof fabric.

FLASHINGS

Among the first things to consider on any roof are the flashings. These are necessary at ridges and valleys, and where dormers, chimneys, or other vertical parts cut the roof. They may be made of tin, zinc, or copper;

the latter is preferable, of course, because of its extreme durability. Flashings in the valleys of a tile, slate, or shingle roof are sheets of metal arranged like a trough, over the edges of which are laid the slates or shingles. Where the slope of a roof is cut by a vertical wall, the flashings consist of aprons turned up against the rising wall, to turn the water from the wall on to the roof.

Figure 88 illustrates the most approved method of putting in flashings; by which due allowance is made for the expansion and contraction of the metal, and for the settlement of the building. The metal strip, A, commonly known as the counter flashing, is inserted in the wall as it is built, and later, when work is started on the roof, the base flashing, B, is laid, and the counter flashing, A, is turned down over it. Where the cost is made subordinate to good work, it is better to use sheet lead for the counter flashings; it lasts longer and can be dressed down well over the base flashings.

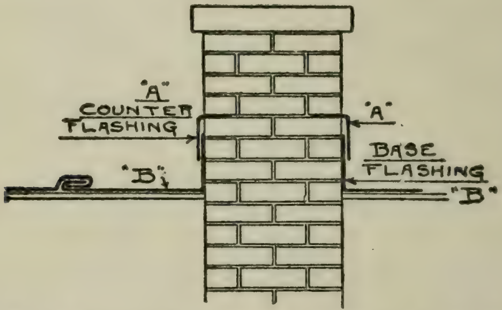


Fig. 88.—Approved method of putting in flashings.

ALLOWANCE FOR CONTRACTION AND EXPANSION

Due allowance must be made for contraction and expansion in every phase of metal roofings; we might call this provision the cardinal feature of the work. Tin and copper roofs must be laid with standing seams similar to those shown in Fig. 89, and they must be secured to the boarding by cleats, and not by nails driven through the sheets. Connections should be made with flashings, metal gutters, and all other parts with locked seams, afterward soldered, and the seams must be contrived so that the water flows past them and not against them.

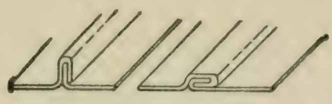
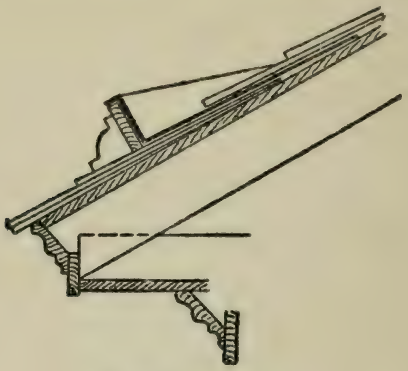


Fig. 89.—Standing seams for metal roofs.

The best grades of metal roofing are usually sold with the name of the brand and the weight stamped on every sheet, and this should be noted for first-class work. The under side of tin roofing is painted with a good grade of metallic paint, such as iron oxide and linseed oil, also the exposed surface, prior to which the roof should be cleaned, especially of all traces of rosin, which might otherwise start rust.

EAVES TROUGHS AND CONDUCTORS

In connection with the roofing there is the installation of eaves troughs, gutters, and rain-water conductor pipes or spouting to consider. See Fig. 90 for several types of gutters. Copper is the best material for this work, though galvanized iron and tin are more extensively used. Care should be taken that the gutters are pitched to drain properly, that all metal surfaces which are concealed are carefully painted, and that the soldering is faithfully done and the connections left free from obstructions. In the case of inside conductors, which are frequently used in conjunction with flat roofs, cast iron soil pipes may be used.


Standing gutter.

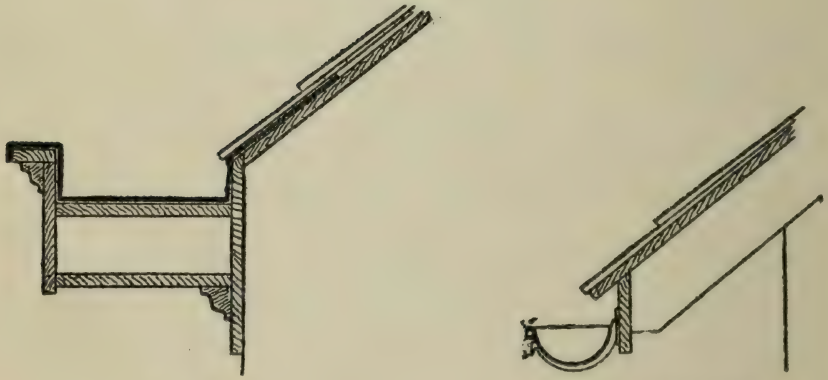

Box gutter. Eaves trough.

Fig. 90.—Several types of gutters.

Slates or tiles will not lie so close to the roof nor to each other as shingles, consequently the boarding should always be matched. And it is best to apply a covering of felt or tar paper over the boards. Both tiles and slates are laid with a variety of joints and laps. They should be put on with galvanized nails, two nails to each piece, or with copper nails, never with plain nails, which soon rust and disintegrate. See that each nail is carefully driven; not too hard, for fear of cracking the slate or tile, yet hard enough to prevent rattling. In good practice the first two or three courses from the gutter, also all hips, ridges, and valleys are laid in a mastic cement.

Never use slate or tile on roofs of low pitch; rain-water has a way of working under the butts, and when this water freezes and thaws it is likely to break the slates. Heavy winds are also responsible for loosening the "leaves" on a flat roof and starting trouble.

POROSITY OF TILE

Most tiles are slightly absorbent; but those that are especially porous should be avoided, as they will not weather well. To ascertain some idea of a tile's porosity there is no better test than to place it in a pan of water and note how much it will absorb. The characteristics of a good tile are density, toughness, uniformity, and a peculiar bloom or surface texture which resembles vitrification.

For fireproof roofs tiles and slates are sometimes bolted to light T-bars or purlins, after which the under side is plastered. Another way is to lay the tiles or slates over terra-cotta blocks which are inserted between the T-bars, to which the slates are nailed or cemented.

TAR AND GRAVEL ROOF

The mode of constructing a tar and gravel roof, sometimes called slag roofing or composition roofing, is comparatively simple. The boarding or, in the case of a concrete roof, the smooth surface of the cement is first mopped with a coating of tar. From three to five thicknesses of tarred felt paper are then laid, each one receiving a liberal application of hot tar, and each sheet lapping the preceding one by a generous margin, and the whole thoroughly mopped with a thick coating of tar. Upon this final coating, while the tar is still hot

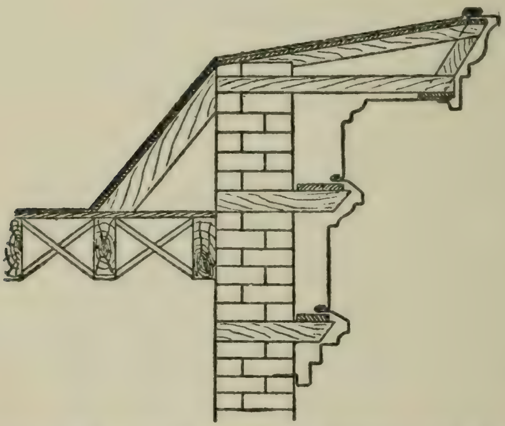


Fig. 91.—Metal cornice to relieve severity of a flat roof.

and in a plastic state, is spread a layer of clean gravel or slag. This stone coating serves as a protection.

Since the durability of the roof depends upon the integrity of the paper membranes, only a good grade of felt should be used, and the tar should not be applied so hot that it will destroy the life of the paper. This is an excellent roof covering, but it should not be used on slopes having a greater pitch than ¾ inch to the foot.

PATENT ROOFINGS

Patent roofings in either shingle, sheet, or roll form should be laid in accordance with the manufacturer's directions which generally accompany every package. When difficulties occur, it is usually because these directions have been ignored. For example, in laying roll roofing it is a temptation to drive a few nails in the center of the sheets. This is a mistake. All roofings contract and expand. This causes a movement of the roofing which, if hampered by a few solitary nails, will gradually cut the fabric around the heads of the nails and open up leaks.

Another common mistake is to drive the nails carelessly, either crooked or too deeply into the fabric, which, of course, cuts it.

I cannot impress upon you too strongly that roofing work of all kinds deserves the closest attention. Also that the time spent in securing a first-class job is unquestionably the best sort of an investment.

CHAPTER IX

ERECTING THE TRIM, STAIRS, AND INTERIOR FINISH

As soon as a building is under roof and the outside walls have been completed sufficiently to exclude storms, work on the interior finish and utilities may be started. Unless circumstances are such that ideal weather conditions are practically assured, or the interior fittings are of a nature not easily affected by exposure to sun and rain, it seldom pays to risk damage to these furnishings until they are offered the protection of the roof.

Experienced builders know this and make every effort to push the shell of the building. They also realize that the time required to complete the interior is often as long, or longer, than the exterior. This is especially true of residential work of the better class, wherein a great deal of the decorative mill work, commonly spoken of as the "special finish," must be measured from the structural portions, then made and assembled in the contractor's joiner shop.

PLANNING THE INTERIOR

Planning the interior of a dwelling or farm building is one of the most interesting phases of the work, and it is also one of the most serious tasks. If a particular arrangement becomes tiresome and distasteful, it cannot be thrown away like an old-style suit of clothes or a worn-out carpet. Interior fittings are installed for all time, unless at considerable expense it is found necessary to alter them. And since much of their real worth depends upon the ease and comfort with which they are utilized or operated, it behooves the builder to give them careful study in advance, and to consult, if necessary, the best authorities available.

Though special skill is not essential, you will find that devising an economical interior arrangement, with means of convenient intercommunication between the different apartments, and at the same time providing adequate lighting and ventilating facilities, is not so easily accomplished. The first rough draft will probably reveal a waste of floor area in unnecessary hall space. This should be avoided. Passageways have no real value in themselves, and besides representing an additional expense to build, they also add to the cost of maintenance—the work of keeping them clean.

In a dwelling the living-room, dining-room, service department, and sleeping quarters should be kept separate as much as possible, and yet not involve a rambling structure. Wings, ells, and angles mean increased expense; the nearer a plan approaches a simple rectangle, the more cheaply it can be erected and furnished. Most of these problems, of course, are taken care of in the original design, therefore the interior finish is but the working out of such details.

SETTING DOOR AND WINDOW FRAMES

With the completion of the roof comes the preparation of the side walls to receive their finish or trim. Among the first things to consider is the setting of door and window frames. In brick structures and most kinds of masonry these frames are set as the masons progress. In wooden structures the door and window openings are usually framed by the studding, to which the sheathing or rough boarding is nailed, and later the frames are added. Sometimes the sheathing is kept an inch or so back from the edge of the studding, as shown in Fig. 93, and the casings of the door and window frames are set flush with the sheathing, and later finished with a piece of molding.

The most common method is to nail the casings against the sheathing, as shown in Fig. 92, which forms a stop for the wall covering—stucco, shingles, or weatherboarding. The top of the casing is flashed with metal, preferably sheet lead on good work, and the bottom of the sill is grooved to receive the shingles or weatherboarding. In exposed localities the casings are made draft-proof by means of canvas strips; in connection with brick and masonry work the cracks between the masonry and the casings are caulked with oakum or similar material. Window and door frames must fit snugly or trouble will be encountered in keeping the building warm.

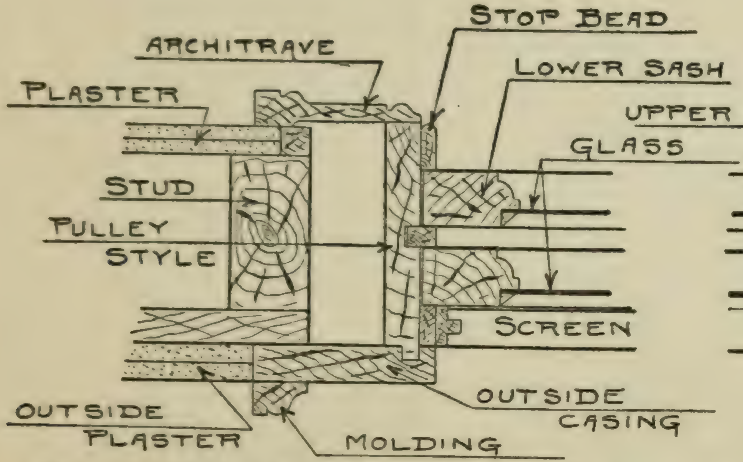


Fig. 92.—Window frame fastened to outside of sheathing.

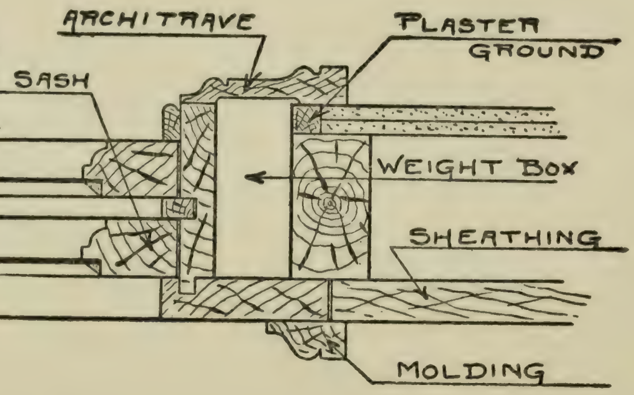


Fig. 93.—Frame set flush with sheathing.

HANGING THE SASHES

In wooden structures the studding is usually made to form one side of the weight box, as shown in Fig. 92, in which event the frame merely consists of the pulley stile and casing. The sashes are held in place by stop beads, battens of wood about ½ inch thick, which should be secured by screws rather than nails. It is often necessary to remove the sashes for some adjustment or other, to repair the cords, or the sashes will swell and bind against the beads, necessitating the relocation of the beads, or planing them, which is much easier accomplished if screws are used.

It is also important that the sashes balance nicely. No great effort should be required to raise them, and they must not fall with a bang when lowered. Inspect the pulleys to see that they are as specified. Often it is hard to detect the difference between bronze-plated hardware and solid bronze material. This hardware is usually installed at the mill.

Cords, chains, and metallic ribbons are used to hang the sashes. The chains and ribbons are the most durable, of course, and they are also correspondingly expensive. For ordinary purposes a good quality braided cord is used. Avoid cheap cotton lines; they generally require replacing in a year or two.

By all means equip sashes with "lifts"—metal devices to afford a hold for the fingers when opening the windows. The habit of raising the sash by gripping the meeting rail, or other wooden bars supporting the glass is very hard on the window. It loosens the putty, racks the frame, and often causes the glass to fall out. Casement or swinging windows require special hardware, of which there is a wide variety for every purpose.

On a job of any size the sashes are seldom delivered with the frames. They are sent later, along with the doors and other portions of the interior finish, when it is known that the structural work is about completed. We are, therefore, getting a little in advance of our work.

PREPARATIONS FOR PLASTERING

As soon as the outside finish is brought to a stage where it affords a protection, the interior of the building is made ready for the plasterers. If the walls are of stone or brick it is customary to build a wooden furring wall just inside the masonry, see Fig. 94. This furring serves several purposes: It furnishes a nailing ground for the lath and interior finish, and, what is more important, it acts as a non-conductor by creating an

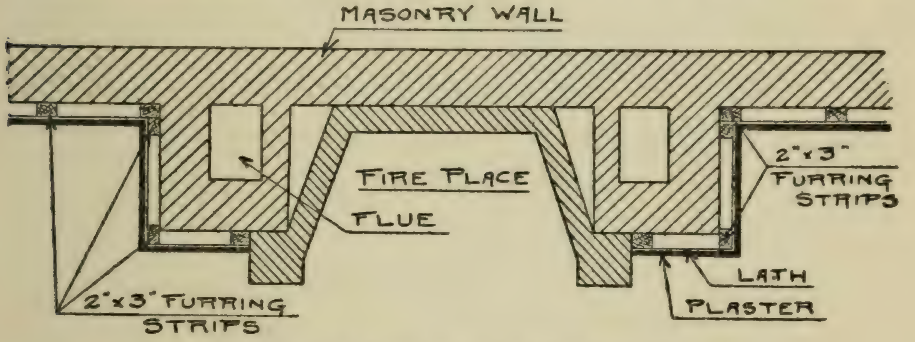


Fig. 94.—Wood furring on inside of masonry walls.

air space between the plaster and the masonry. Sometimes the plaster is applied directly to the masonry, but then there is always the danger of dampness or moisture being transmitted through the masonry to the interior.

Hollow tile and hollow brick walls avoid this risk by reason of the air spaces in their centers or cores. In concrete work the danger is minimized by the use of a waterproofing compound.

FURRING

Furring timbers are 2 x 3″ laid on their flat, or 1 x 2″ shingling lath, spaced on 12- or 16-inch centers, secured to the masonry. Spikes are driven into the mortar joints, or wooden nailing grounds are inserted in the masonry, to which the furring strips are nailed. Furring strips are also laid around chimneys and fireplaces to form a surface for plastering, which greatly obviates the likelihood of cracks due to settlement.

In ordinary structures the partitions are made 4 inches thick, the same as frame outside walls, therefore 2 x 4″ studding is used to advantage. These partition studs are usually placed on 16-inch centers and filled in between horizontal pieces at the floor and ceiling, called a cap and sole. It is unwise to space the studs farther apart than 16 inches, even in the lightest work, for a wider span places too great a strain on the lath, which is apt to sag.

LATHING

As soon as the framework is completed the lathing is started. In many localities this phase of the work is done by a special set of mechanics. It is a distinct trade; men become expert lathers and will do nothing else, though with the increasing use of metal lath, which does not require such dexterity, the specialty is gradually dying out.

Before the lathing is begun see that all rough work is properly in place—examine the walls, ceilings, and soffits to see that they are true, level and plumb, note that the angles are fair, and that sufficient grounds are in place for the interior wood finish, also corner beads for the plaster.

Three-eighths inch is the correct space between wooden laths. Insist that this rule be followed. There is a tendency to fit laths too closely together, consequently insufficient mortar is pressed through the cracks to form an adequate key. On the contrary, if the laths are spaced too far apart the mortar will not sustain its own weight.

Another rule to be remembered—the direction of the lath must never be changed in the same panel; otherwise cracks are almost certain to appear in the plaster. There is no objection to running laths diagonally, but their directions should not be mixed. The matter of breaking joints is another aid to good work. All laths should be broken every sixth course on the walls, and every other lath on the ceiling. Over doors, windows, and other openings the reliable mechanic will aim to carry the laths to the stud beyond, to avoid cracking of the plaster. (See Fig. 95.)

Metal lath is widely used as a substitute for wood lath. It holds the plaster more securely than wood lath, consequently there is less cracking, and by reason of its fire-resisting qualities it comes highly recommended. There are numerous brands on the market, and it will pay you to investigate them. Write to the manufacturers for samples and prices.

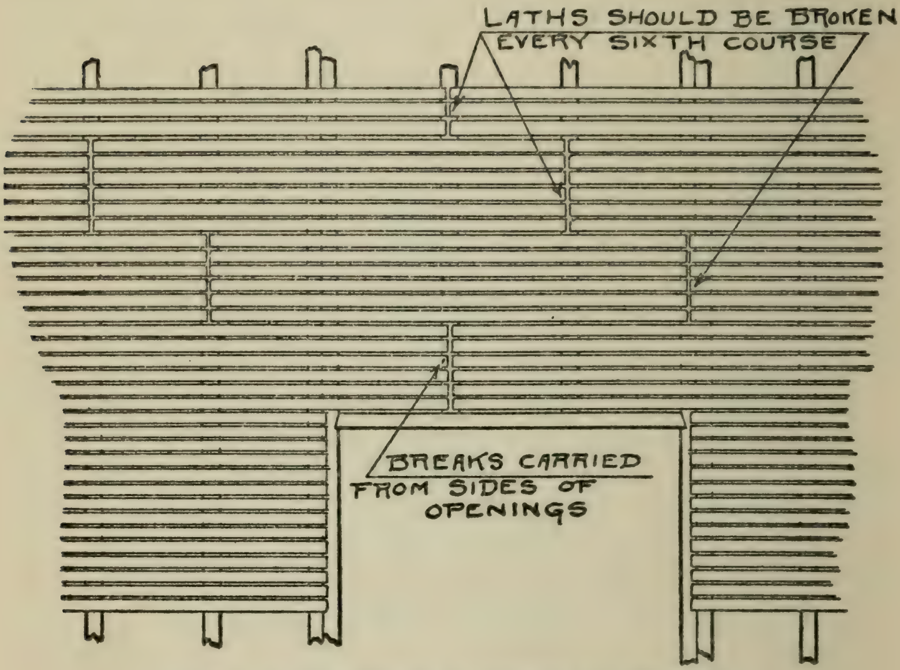

LATHS SHOULD BE BROKEN EVERY SIXTH COURSE
BREAKS CARRIED FROM SIDES OF OPENINGS

Fig. 95.—Good method of putting up wood lath.

HEATING AND PLUMBING PIPES, ELECTRICAL WIRING

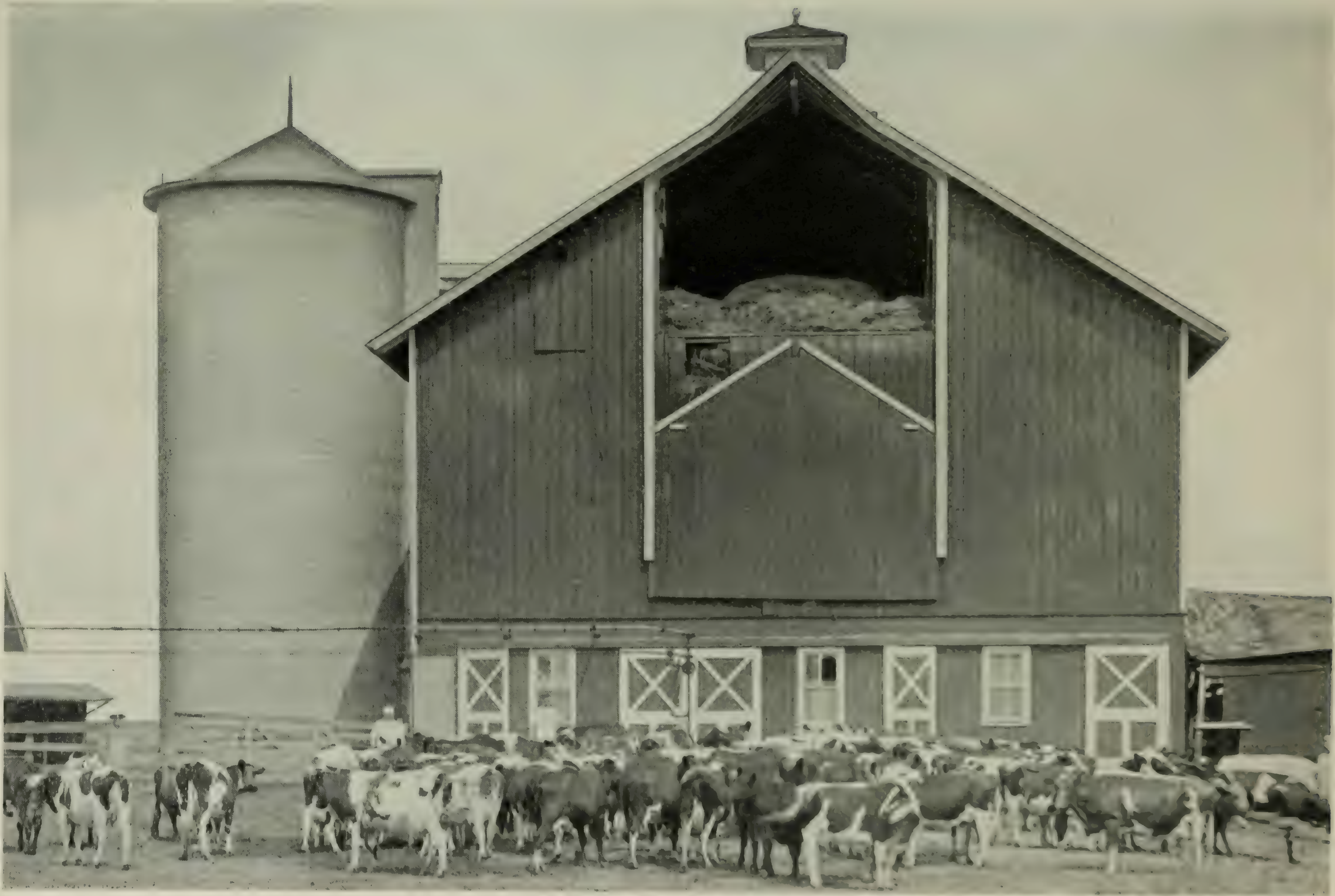
Though it is quite common to run the heating pipes and sometimes the plumbing pipes outside of the plaster, that is, within the interior of the rooms, unless this plan represents an appreciable saving or other advantage, it is not a good-looking arrangement. Heating pipes are not so objectionable as plumbing pipes, especially soil lines. Wherever possible run them up through the partitions, which means that this work should be done before the lathing is completed. Gas pipes and electrical wiring are two other factors to be considered at this time. Both of these branches of the work can be installed in a couple of days, hence they should not cause any delay. See that the outlets to receive fixtures are strongly secured to the framework, and not to the lath, to prevent sagging and cracking of the plaster.

The plumbing fixtures, electric light fixtures and switches, heating apparatus, and so on should not be installed until after the plastering is done. Only the piping leading to the fixtures should be put up at this time, and pains should be taken to protect all openings to this piping. They should be carefully plugged or covered with canvas to prevent foreign matter from falling into them. Plastering, as you are no doubt aware, is one of the dirtiest jobs in the building trade, and against which all other work must be protected.

SCREENS FOR PLASTER

On first-class work before the plastering is started the windows and doors are covered with a light cotton cloth, or else fitted with screens of similar material. These are necessary in cold weather to protect the plaster from freezing, and in warm weather to prevent the plaster from drying out unevenly near the openings. Plaster and cement should dry uniformly, from the inside out, and from one corner of the room to the other. If not, they are likely to check and crack.

The preliminary part of mixing the plaster should start about a week before the actual work is contemplated. First the lime is slaked and converted into a putty, the sand is carefully screened and thrown into convenient piles, and the necessary hair is prepared, which consists in freeing it from a compact mass. Allow the lime to slake for a couple of days before adding the hair, otherwise the heat from the lime is apt to slightly burn the hair and thus impair its strength. Thoroughly beat up the hair through the paste, using a vigorous motion of the hoe, after which the requisite amount of sand is added and the whole mass allowed to stand for about a week. When ready to begin work, small quantities are spread out on the mixing platform, water is added, and the mass is tempered to the proper consistency.



Gable-roof stock barn fitted with labor saving equipment

APPLYING THE PLASTER

The first coat of plaster must be troweled with sufficient pressure to force it into the meshes of the wire lath, or between wooden laths. In two-coat work this first layer is put on thick enough—about $\frac{3}{8}$ inch—to come within $\frac{1}{8}$ inch of the finishing surface, as the finishing coat is simply a thin veneer of lime putty and fine white sand. Before the first coat hardens it is scratched with a saw-tooth paddle or wire brush, to offer a roughened surface for the finishing coat, hence the first coat is generally spoken of as the "scratch coat." In three-coat work, which is generally specified for first-class jobs, the first coat is put on about $\frac{1}{4}$ inch

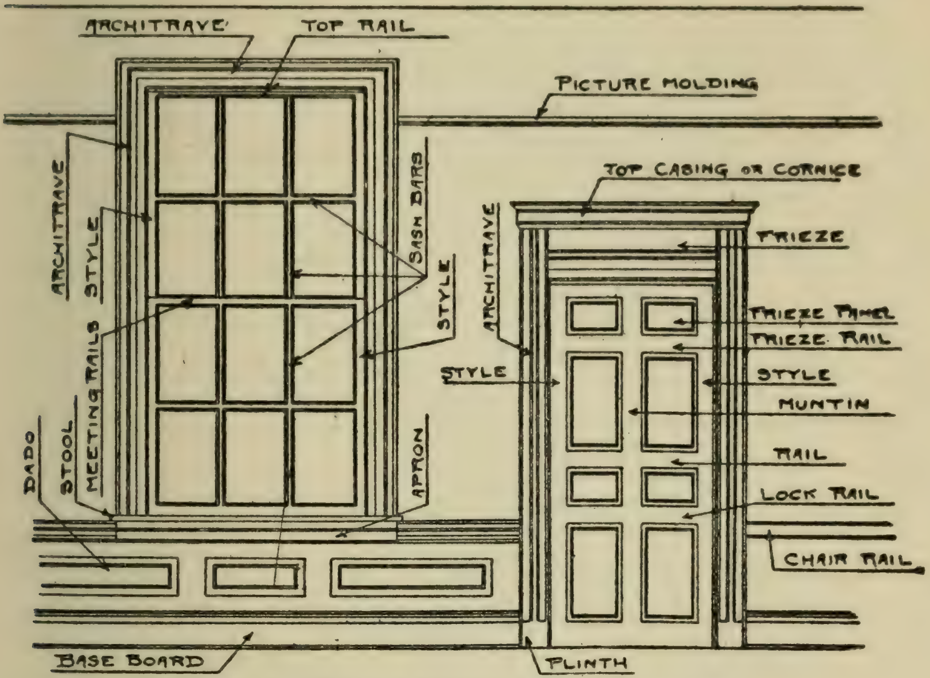


Fig. 96.—Typical interior finish for dwelling.

thick, this is scratched, and a second coat is applied about $\frac{3}{16}$ inch thick. The final coat is a skimmed coating of plaster-of-Paris mixed with marble dust and lime putty, commonly called the "white coat."

WALL BOARDS

Partly because of the dirt and inconvenience occasioned by plaster work, and because it requires more or less favorable weather conditions in which to dry out, also because experienced workmen are required to do a good job, numerous other materials have been manufactured to take the place of regular plaster. Among these are plaster board, gypsum blocks, composition ceilings, and various other combinations of wood fiber, paper stock, asphaltum, asbestos, felt, and other vegetable and mineral substances.

The advantages claimed for these wall boards are that they combine the labor and material of lathing and plastering, that they can be put on regardless of weather conditions, which speeds construction, especially during the winter months, and that they are fire-resistive, non-conductors, and sound-deadeners, and that they are not subject to cracks, stains, and other defects common to ordinary lath construction. Wall paper, paint, canvas, burlap, or any of the regular forms of decoration may be applied to them, without the inconvenience of waiting for ordinary plaster to dry. The more reliable makes are guaranteed not to warp, buckle, chip, or deteriorate with age, and that heat, cold, and dampness have no effect upon them.

Unquestionably, these boards do fill a long-felt want, especially among farmers and those who do their own building, and who are not competent to execute a good plastering job, but they are not likely to replace lath construction under ordinary circumstances. Wall boards are easily and quickly put up, and they can be utilized in a surprising number of ways. They are usually made in sheets 32 and 48 inches wide, to take the widths of two or three studs spaced on 16-inch centers, and any length up to about 120 inches. They are cut with an ordinary saw, knife or chisel, and are easy to handle because of their flexibility. Most of them have a thickness of $\frac{3}{16}$ inch, and about the same rigidity as wood.

They are found especially desirable for bungalows, garages, light frame structures, temporary offices, attics and farm buildings, and are also used in many of the largest stores, factories, hotels, office buildings, and public institutions. The average cost per square foot is about the same as lumber. They are for sale by lumber yards, builders' supply houses, hardware and paint dealers, or by the makers direct.

Each manufacturer accompanies his product with explicit directions for applying it, or such instructions may be had for the asking, and they should be carefully followed. Pay particular attention to the remarks on contraction and expansion, since these are the potent factors toward a satisfactory job. As a general rule it is advisable to store the boards for a few days under the precise conditions in which they are to be used, with the view to having them undergo any contraction or expansion before they are put on the walls. Another safe rule is—not to butt the sheets too closely together, so that by chance if they do expand there is due allowance for this movement; otherwise the sheets may buckle.

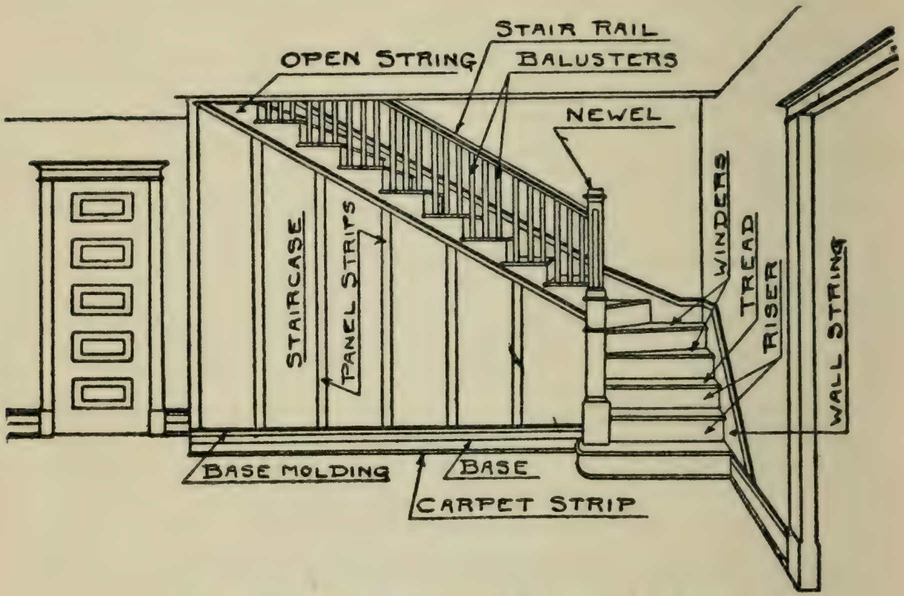


Fig. 97.—Typical woodwork in way of staircase.

STAIR BUILDING

We will now concern ourselves with the subject of stair building—one of the most vital parts of the interior, and about which so many unnecessary blunders are made. It is strange, perhaps, though stairways are among the most commonplace parts of a structure, they frequently are the least understood by designers and carpenters, especially the latter. In the large cities it is therefore customary for stair building to be followed as a special trade.

The stairway is not alone important as a utility, but also in point of appearance. Often the first impression of a building is gained by a view of the stairs, and if this is objectionable the structure is discounted, if not condemned, as undesirable, notwithstanding there may be many other commendable features.

Stairways should be as commodious as possible and comfortable to ascend and descend. Nothing is so lacking in hospitality and so obtrusive to eye, nerve, and body as a narrow, contracted, improperly laid out, steep set of steps. The question of head-room is equally important, though not so easily foreseen. Many flights of stairs, otherwise well designed, are rendered totally unsatisfactory by insufficient head-room. This factor, of course, is influenced mainly by the height between floors and the space allowed for the staircase.

Before proceeding with the subject, let us review some of the definitions, as shown in Fig. 98. The *rise* of the stairs is the total height from top of lower floor to top of upper floor; the *run* is the length of the floor occupied by the stairway; the *pitch* or line of nosings is the angle of inclination of the stairs; and all three dimensions determine the mode of construction.

The body or staircase is the room or space in which the stairway is contained; the tread is the horizontal surface of the step upon which the foot is placed; the riser is the vertical height of the step, or the distance between each tread; the string-board is the side of the stairway, connecting and supporting the ends of the steps. If the steps are housed or grooved into the string-board, it is called a housed or closed string; if the steps rest upon miters cut to the proper angles to receive the ends of the treads and risers, it is termed an open string. The wall string is the support of the steps against a wall.

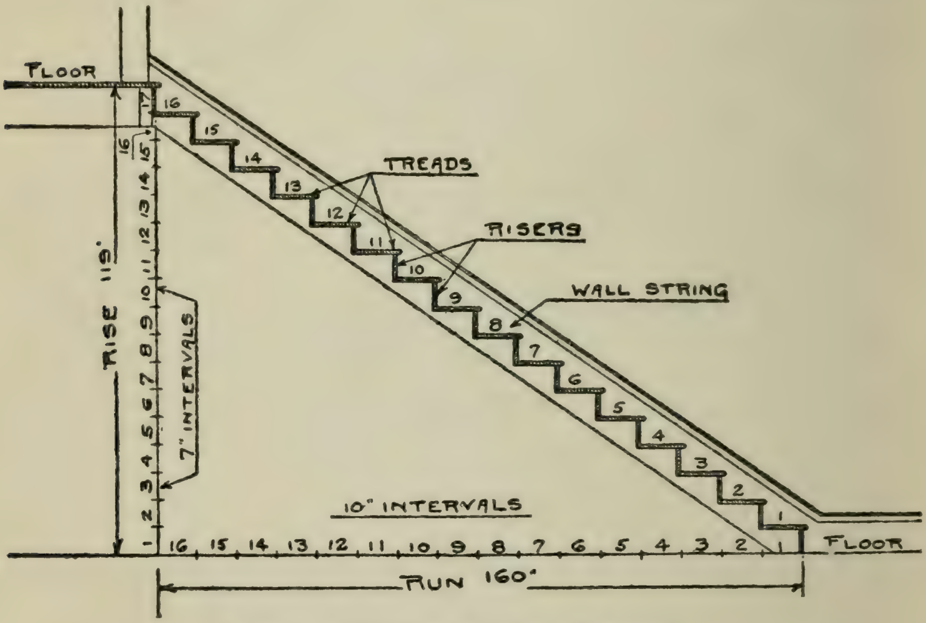


Fig. 98.—Layout of a flight of stairs.

The height of the riser and the width of the tread are usually governed by the dimensions of the staircase, but for a general rule the tread should not be less than 9 inches wide, and the riser not over 8 inches high. In practice we find that a 7-inch riser with a 11-inch tread makes an easy stepping flight of stairs. Generally speaking, if you increase the width of the tread you must reduce the height of the riser; the tread and riser together should not exceed 18 inches, except in special cases, such as the stairways to large hotels, railway depots, and public buildings.

LAYING OFF TREADS AND RISERS

In planning a flight of stairs the first thing is to lay off the exact position of the first and last risers. The distance between these points is then divided by the width of the tread desired. If this tread is 10 inches, and the total distance is 160 inches, then 16 treads are required. It will be understood that the number of risers is always one greater than the number of treads, by reason of the fact that the upper floor acts as the final tread. Thus 17 risers are required.

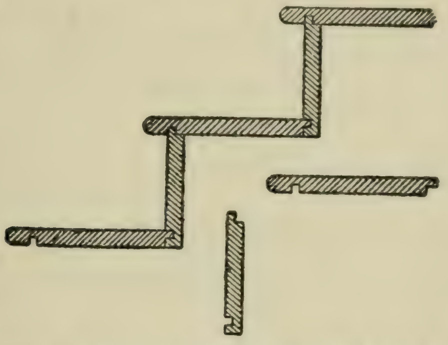


Fig. 99.—Sectional details of treads and risers.

The height or rise of the story is considered next. Suppose this measurement is 9 feet 11 inches, or 119 inches. We have 17 risers to place in this space, consequently, if we divide 119 by 17, we get a quotient of 7, which is the height of each riser in inches. The first riser will be narrower than the others, because the thickness of the first tread, which corresponds to the lower floor is taken off.

The steel square is invaluable in stair building, a study of which will materially simplify the method of laying out the different timbers and parts.

TRIM OR FINISH

Let us return to the other woodwork—the doors, base boards, chair rail, dado, wainscoting, picture molding, door and window casings, or architraves, all of which comprise the trim or finish. This work is seldom started before the plasterers and other mechanics have finished and the house is virtually ready for decorating. (See Fig. 96.)

The woodwork surrounding the doors and windows on the inside of the house, and which is nailed over the plaster, is specified as the architrave, though, perhaps, a more common term is "casing." There are two chief methods of applying this casing, one is by the block, as shown in Fig. 100, or with the miter. The former is the easier to erect and less likely to be disfigured by shrinkage or careless measurements, which will cause unsightly joints to appear.

The dado, wainscoting, and chair rails are considered in connection with the architraves. Sometimes where a dado is used its cap molding will be put in line with the window stools. Or it may be advisable to run the chair rail on a line with the window aprons. Wherever possible this finishing woodwork should be erected without splicing, and every member should be securely nailed to the walls with small-headed nails, well set for puttying, with the nails driven in the quirks of the moldings so that they show the least. Beware of hammer marks; they are the imprints of carelessness. After the trim is in place it is sand-papered to remove all traces of the milling and made ready for the painters.

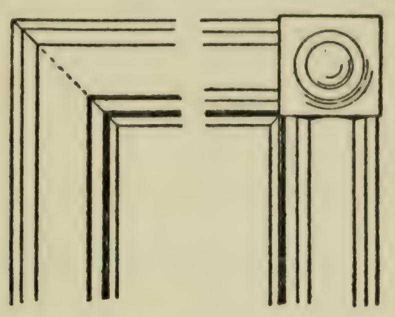

Mitred architrave. Block architrave.

Fig. 100.—Typical door and window casings.

HARDWARE

The greater part of the hardware, such as window lifts, door knobs, escutcheons, push plates, handles, cupboard turns, bell and switch plates, hooks, and so on, frequently dubbed the "furniture," is put on after the painting is completed so that it will not be splashed or marred in any way. This work calls for the services of a very careful mechanic, preferably one who is accustomed to such jobs.

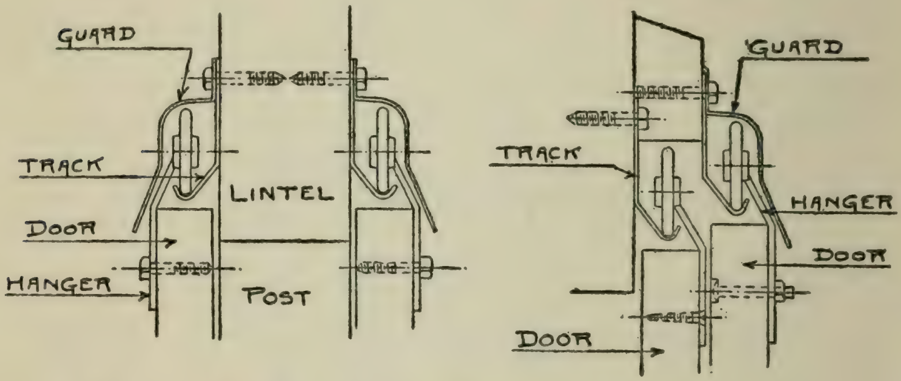


Fig. 101.—Methods of hanging barn doors to pass each other.

In the construction of barns, stables, and other farm buildings a careful study should be made of the equipment intended for these structures before the actual work is started. Stalls, stanchions, mangers, pens, and carriers all require a particular fastening or foundation, for which provision should be made as the structural work progresses. For example, while a roof is being shingled is the best time to put up the hay carrier tracks. They can be secured to the rafters with ease from the outside of the barn, since the roof forms all the scaffolding necessary; whereas after the barn is completed the work will have to be done from below, with the aid of tall ladders and scaffolding, depending upon the height of the barn.

In building work of any description never lose sight of the different branches of the operation. The far-seeing mechanic is the fellow who puts up the best job with the least money. He is constantly trying to "kill two or more birds with the one stone."

CHAPTER X

HOW TO INSTALL A SANITARY DISPOSAL SYSTEM

EVERY year the farmer is getting farther from the idea that he must content himself with the primitive and ofttimes insanitary conditions of his forebears, and that by reason of his distance from a municipality he cannot aspire to the conveniences and creature comforts of a modern dwelling—improved heating, lighting, and plumbing—which are deemed so imperative to the ordinary welfare of his city brethren. Indeed, the farmer has come to realize that failure to employ modern methods not only imposes unnecessary hardships on the members of his household, but their absence is frequently a constant menace to good health.

Hygiene and sanitation are as essential on the farm as in the city; but probably because there is no congestion in the country there has been a tendency to disregard their importance.

Improved heating and lighting both contribute to the health and happiness of a household; but a modern plumbing system is, without question, the greatest convenience; and when this is installed on a farm or country place where there is no public sewer to connect into, other means must be provided to carry off and destroy all waste as quickly as possible. The cesspool was first designed to solve the problem; but the idea, name, and operation were equally odious and unsatisfactory. The cesspool only put the trouble out of sight temporarily, and, in reality, established a nuisance—a storehouse of putrefaction.

HOW THE SEWAGE IS ELIMINATED

The principle of a modern sewage disposal system is precisely what the name implies—it disposes of the refuse in a sanitary, economical manner by mechanical and natural processes. As the result of many investigations and experiments it has been found that certain micro-organisms, technically known as anaërobes, because they thrive without air, are capable of reducing solid organic matter to liquids and gases. Other bacteria, called aërobes, which are present in all fertile soils, have the power to purify the liquid product by oxidation and nitrification, and thus convert dead organic matter into pure water and harmless mineral elements needed for vegetable life. They are Nature's methods of ridding the earth of undesirable animal matter, and are at our disposal everywhere if only we provide suitable conditions for the bacteria to multiply and work to the best advantage. The system or laboratory for this bacterial transformation is simple in its construction, inexpensive, and consists mainly of two operations: the collection of all waste matter into a septic tank, and a subsequent distribution to the soil

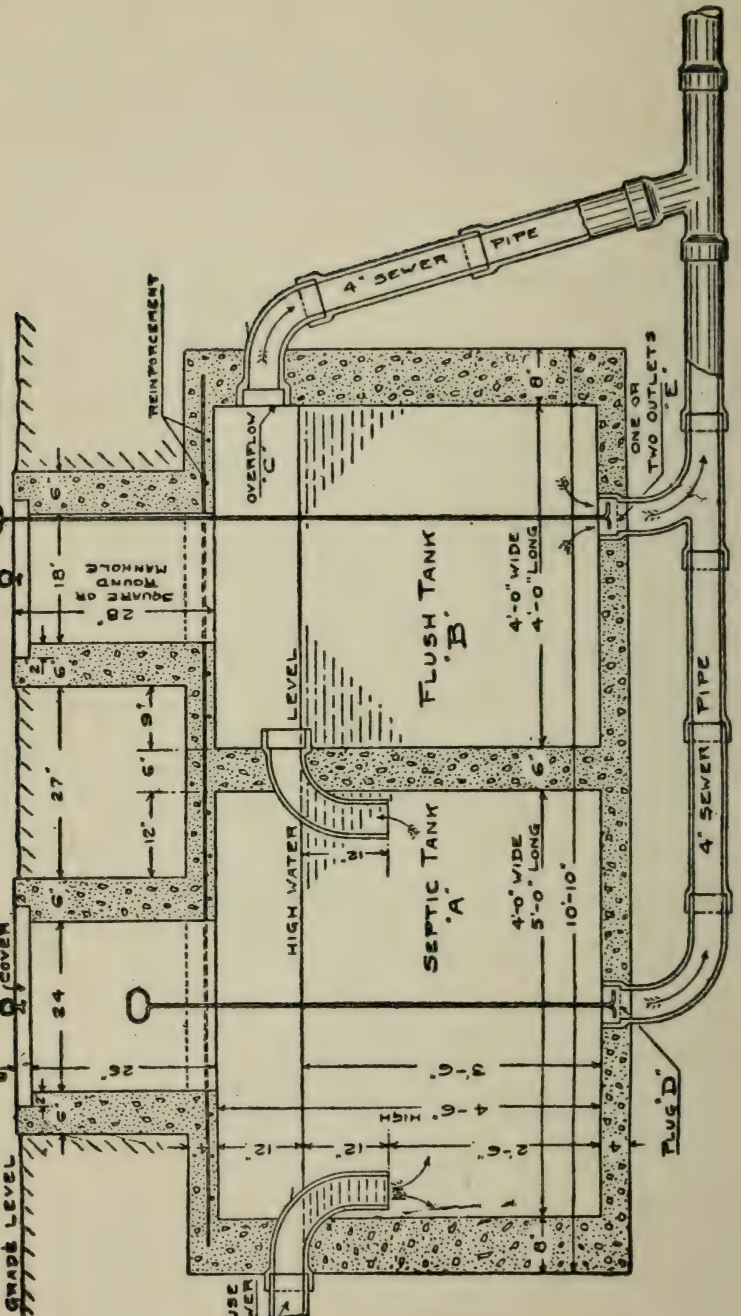


Fig. 102.—Cross-section, showing arrangement of septic tank.

by subsurface irrigation. The first step converts the solids into liquids and gases, and effects about a 40 per cent. purification. The second operation oxidizes or burns up the impure gases and thereby completes the purification.

SETTLING CHAMBER

The basic idea, then, or keynote to a successful plant lies first in providing a suitable settling chamber, where the raw sewage may become finely divided or highly diluted; second, in applying the diluted product to the soil alternately with plenty of air, or what is termed the "intermittent method" of operating a plant. The theory is quite apparent: the aërobes or bacteria live in the air in the soil near the surface of the ground, and should be fed with the sewage—but not drowned in it. They must have a breathing spell, so to speak. Hence, if sewage is applied continuously and in such a concentrated form that the system is kept saturated, the filter or disposal area becomes water-logged or "sewage sick" and ceases to be effective.

VOLUME OF SEWAGE

The volume of sewage from a dwelling is practically equal to the water consumption, which will average about 50 gallons per person per day where there are the customary plumbing fixtures. The actual quantity of waste matter is very small, hence it will be seen the dilution is very high even before the first bacterial action has taken place. From twenty-four to thirty-six hours are required for the anaërobes to complete their work, whereupon the liquid product discharges into a flush tank ready for distribution to the soil.

On the larger and more expensive systems the flush tank is equipped with a siphon which automatically discharges the liquid product at regular intervals; and usually the disposal area consists of two distinct tile fields, used alternately, and controlled by a diverting gate. The system herein described, however, is designed to meet all requirements at the minimum initial cost and maintenance charges, and of such simplicity that anyone with the most ordinary mechanical ability—not necessarily a sanitary engineer—may easily construct it. We will therefore eliminate the siphon and diverting gate for economical reasons only.

SEWER FROM HOUSE

In this chapter it will be assumed the plumbing fixtures and soil lines have been installed in the dwelling in a careful, workmanlike manner, and the house drain of cast-iron pipe has been fitted with a main trap, and the iron pipe carried 5 feet from the foundation walls. From this point to the septic tank or settling chamber standard vitrified sewer pipe may be used, usually of 4-inch diameter, and laid with tightly cemented joints. The fall or grade should be about $\frac{1}{8}$ inch to the running foot, and not less than 6 inches to 100 feet. On the other hand, if the grade is excessive the velocity of flow must be checked in some way before entrance to the septic tank, otherwise it will cause too much disturbance to the surface scum.

LOCATION OF SYSTEM

Where plenty of land is available the settling chamber should be located about 100 feet from the house, preferably on a hillside or slope where there is a natural, good drainage, and it may underlie the lawn or garden with absolute security. A sandy loam is the most suitable for a disposal field, yet if only a heavy clay is available it may be made effective by underdraining or by partly filling in the trenches with broken stone, gravel, or cinders, and thereby constructing a sort of French drain.

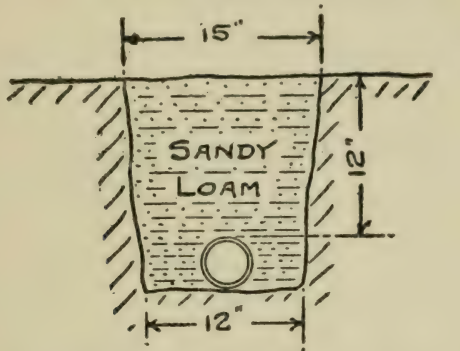


Fig. 103.—Method of laying tile in porous soil.

PROPORTIONS OF TANK

The septic tank and adjoining flush tank should be as nearly water-tight as possible, and may be constructed of masonry, brick, or concrete; although concrete is the most adaptable, and usually the most economical and easiest to build. The capacity of the settling chamber "A," as shown in Fig. 102, should be large enough to store twenty-four hours' sewage, and preferably thirty-six hours' supply, but no greater, or putrefaction is likely to take place. The sewage must come fast enough to feed the anaërobes, but not faster than they can reduce it to liquid form. On the basis of eight members to a household, each having a daily water consumption of 50 gallons, the dimensions of the settling chamber should permit a storage of 500 gallons, or 67 cubic feet at high-water level, which should be about 12 inches below the top of the tank. The proportions of the chamber may be made as desired, although it is advisable to have the depth not less than 4 feet, in order to allow the raw sewage an opportunity to settle and liquefy before passing into the flush tank. The dimensions as shown in diagram, 5 feet long, 4 feet wide by 4 feet 6 inches high, are figured for a household of eight persons. Note that the capacity of the flush tank "B" —4 feet long, 4 feet wide by 4 feet 6 inches high—is somewhat smaller than "A," for it is customary to distribute the partly purified sewage at intervals of twenty-four hours. Should this regular daily attendance be overlooked, however, the flush tank is fitted with an overflow at "C" which connects with the disposal area. The septic tank "A" is sometimes equipped with an overflow also, though this precautionary measure is hardly necessary where a plant receives daily attention.

The inlet pipe to the settling chamber and the outlet to the flush tank should be fitted with elbows extending 12 inches downward. This arrangement prevents any serious disturbance to the surface scum, which would retard the bacterial action, and is of the greatest importance. There is a slight accumulation of solids in the bottom of the settling chamber, such as mineral matter, which resists decomposition, and this sludge should be removed or drained off every couple of years. To facilitate this operation the settling chamber may be equipped with a valve "D," controlled by an iron rod as shown in diagram. The mineral sediment then passes off into the disposal field.

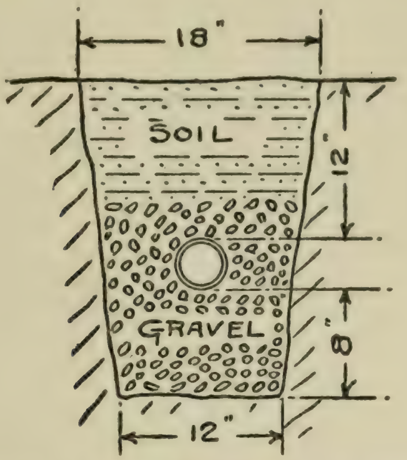


Fig. 104.—Method of aërating heavy soil by means of gravel.

FLOODING TILE FIELD

The second and final step toward purification is in the application of the contents of the flush tank to the soil; and, as previously mentioned, this operation should be intermittent, to allow aëration. Without a siphon, it is necessary to release the flush tank by hand once a day —an operation that should not take more than ten minutes of a boy's time, and is controlled by the plug or valve "E" being lifted upward and replaced when the tank has emptied into the disposal field. This floods the entire tile field, whereas, if there were a small, continuous flow from the flush tank, that portion nearest the tank would absorb it all, and soon become saturated and foul. The bacteria in this section could not live for lack of air, while those in the farthest laterals would

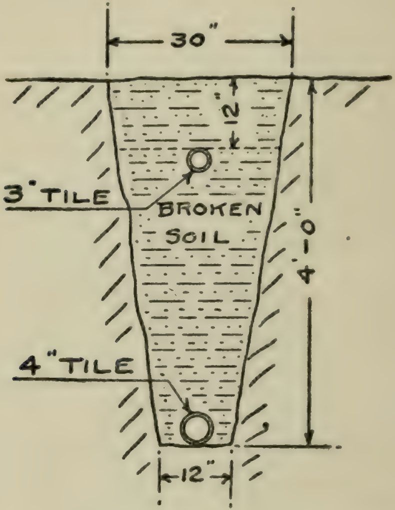


Fig. 105.—Method of underdrainage.

not thrive in large numbers from lack of sewage to feed upon.

Sanitary results could be accomplished by surface irrigation, but for esthetic reasons it is well to employ

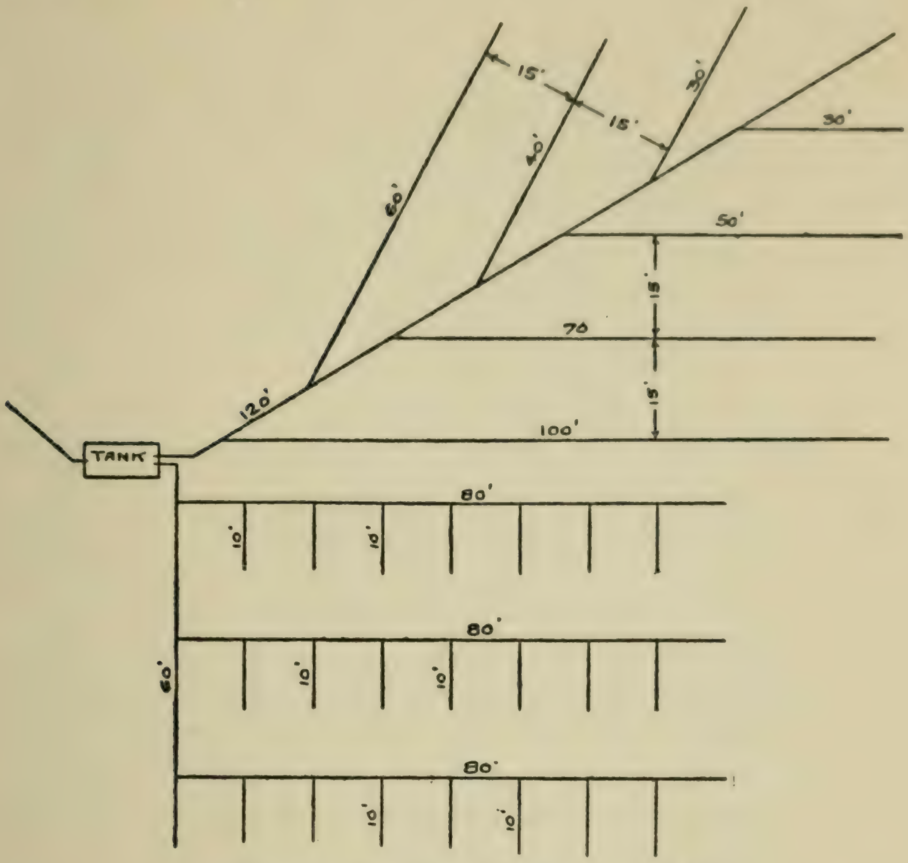


Fig. 106.—Two plans of laying out tile field.

drain-tile or sub-surface irrigation. Any ordinary type of porous, agricultural tile may be used, 3 or 4 inches in diameter, which may be purchased for about 4 cents a foot. The tiles should be laid about 12 inches below the surface of the ground, as shown in Fig. 103, with open joints, and nearly level. If laid with a perceptible grade, the distribution will be unequal and the lowest sections will be unduly flooded. The length of tile required and the distance between the rows of tile will depend upon the porosity of the soil. Fifteen or 20 feet is the customary intervals for a sandy loam, allowing 1 foot of tile for each gallon of sewage in the septic tank. For a heavy clay soil, 2 feet of tile per gallon should be allowed. Figure 104 illustrates a method of aërating heavy soils by the use of gravel, broken stone, or cinders. If the stratum underlying the surface is particularly impervious, it may be underdrained successfully as shown in Fig. 105, with a lower line of tile that has a free outlet; or equally good results may be obtained if two distinct lines of tile are laid, and used alternately. It is then necessary to fit the flush tank with two outlets "E" as marked on diagram.

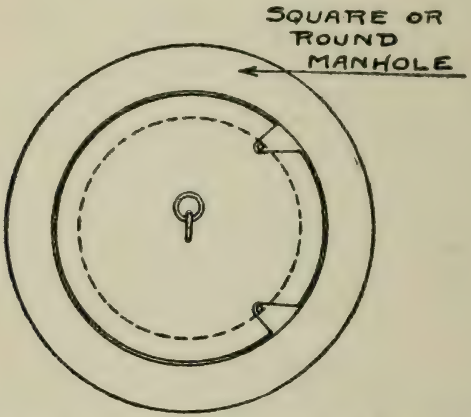


Fig. 107.—Cover for top of tank, showing handles for flushing system.

Figure 106 suggests two plans for laying out the tile;

they may be deviated from as local conditions require. No fears need be felt that the tile field will freeze in winter; for the heat contained in the sewage, which is generated by the oxidizing process, will keep the ground open.

Provision should be made for access to the tanks either by circular or square concrete or brick manholes, equipped with close-fitting covers—of concrete, iron, or wood. The valve handle to the flush tank should be so arranged that it is not necessary to remove the manhole cover to operate it, as will be noted in Fig. 107.

GREASE TRAP

Experience has proved that it is essential to provide means for separating and eliminating grease from the kitchen sink; otherwise the grease will collect in large quantities and ultimately clog the system. The scheme shown in Fig. 108 is a simple, efficient arrangement, and may be installed at a cost not to exceed $5.00 for materials. The reservoir consists of three lengths of large diameter sewer pipe, stood vertically, with cemented joints and floor, and a 3-inch terra-cotta pipe as an outlet, so arranged that the high-water level is below freezing, yet the mouth of the outlet is at all times below the surface of the sewage. Being lighter, all grease will float to the surface, and is thus prevented from entering the outlet, which is then connected to the main sewage line, thence to the septic tank. A concrete slab or manhole cover, similar to those used on the settling chamber, should be provided for the top of the grease trap. As the grease scum accumulates in large quantities, perhaps twice a year it may be removed and spaded into the earth.

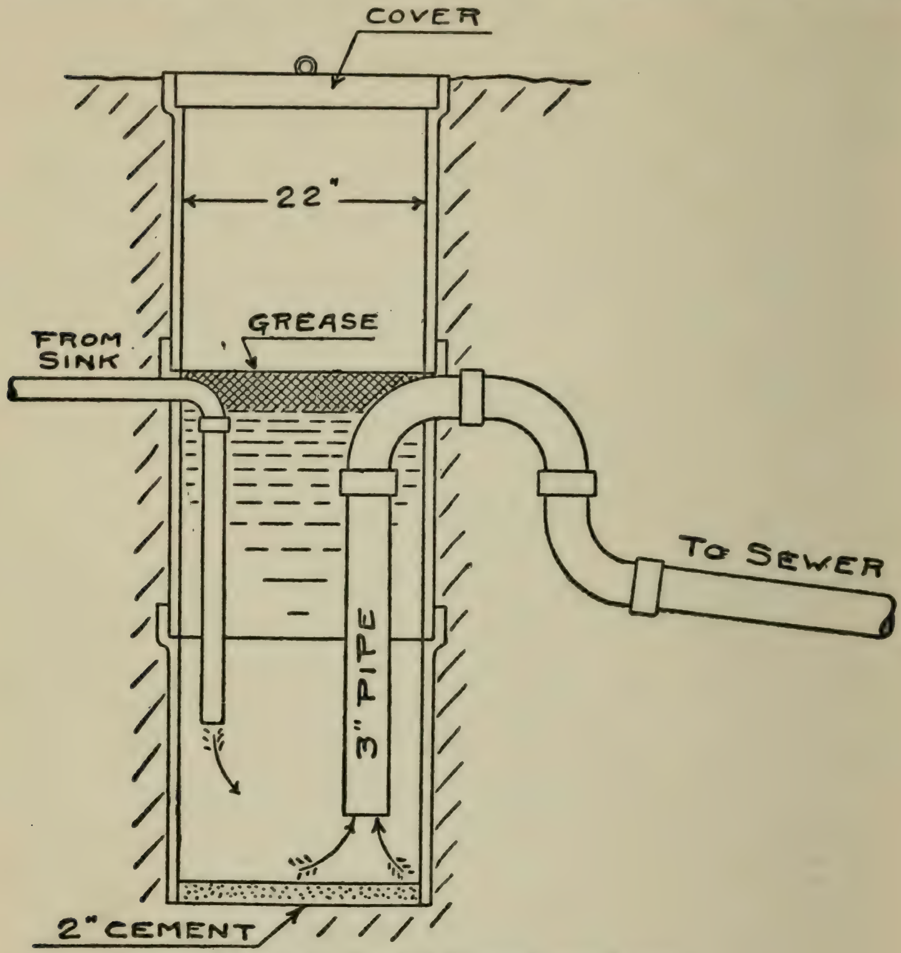


Fig. 108.—Section through grease trap.

HOW TO BUILD SETTLING CHAMBER

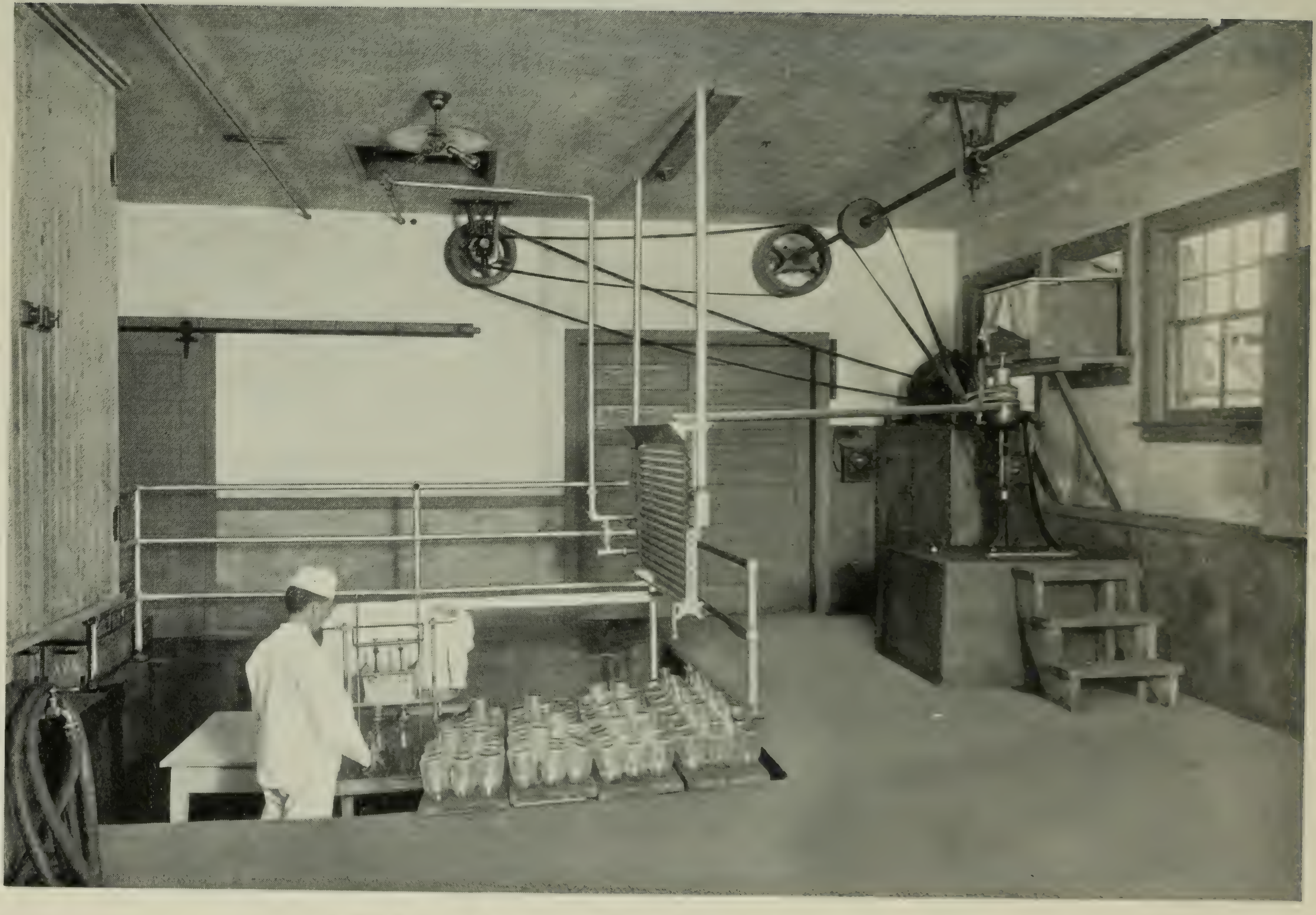
The excavation for the settling chamber and flush tank should be made as neat and accurate as possible, for it is then practicable to use the earth bank for an exterior form, and thereby reduce the amount of lumber and carpentry work. Lay the floor first, and at the same time insert the necessary terra-cotta elbows and tees for outlets. Then erect the form work, or boxes, for the two tanks; once again insert the elbows in their proper position, and pour the walls of the cistern in a continuous operation. The concrete should be mixed in the following proportion: One part of a good grade of Portland cement, 2 parts of clean, sharp sand, and 4 parts of broken stone or pebbles that are almost 1 inch in diameter. The roof or ceiling of the cistern will require reinforcement of some kind—either light iron rods, pipe, or heavy wire will answer the purpose—which should be embedded in the concrete as it is poured, and kept near the lower surface, as shown in diagram.

MATERIALS REQUIRED

On page 202 is a list of the materials required for the disposal plant for eight persons described in this chapter, together with an approximate estimate of their cost. No labor charges have been considered for excavating and laying sewer and tile pipe; for the greater part of this work may be done by plowing, or with farm help.

Where a farmer is able to do his own carpentering work on the forms, and there is old lumber available, the above estimate may be cut down appreciably. In many cases sand or pebbles will be found on the premises, which will greatly reduce the cost of the concrete.

Excavation for tanks, 16 cu. yds. @ 30c	$ 4.80
Concrete for tanks, 7 cu. yds. @ $6.00, including all labor and material	42.00
Forms for concrete, including carpenter's wages and new lumber	40.00
Iron work—valve handles, reinforcements, etc.	2.50
Terra-cotta sewer pipe and connections	22.50
500 ft. porous tile, @ 4c	20.00
Freight and hauling material to site	40.00
	$171.80



Well equipped, sanitary milk house on a model dairy farm

CHAPTER XI

CONCRETE FENCE POSTS

FENCING is always an important factor on the farm or country place where live-stock abounds, and the type or style should be given careful consideration with regard to the initial cost of erection, efficiency, durability, and appearance. Our forefathers solved the problem with split rails and stone walls, and both were picturesque and economical in their generation. What few remain are still picturesque and quaint, but they would not be economical to replace.

A hundred years ago, when timber was plentiful and vast areas were wooded and had to be cleared for farming purposes, it was comparatively cheap to split trees into rails and convert them into fences. In a similar fashion, when a farm had to be cleared of stones and boulders, it was much easier to drag them to the boundaries and there lay them up in a wall, than to dispose of them elsewhere. Today, however, timber is no longer plentiful nor cheap; rail fences have weathered into oblivious decay, the stone walls have been gradually appropriated for other purposes; consequently, where these venerable landmarks of pioneer days have been overtaken by old age and have passed their period of usefulness they must be replaced by another means—

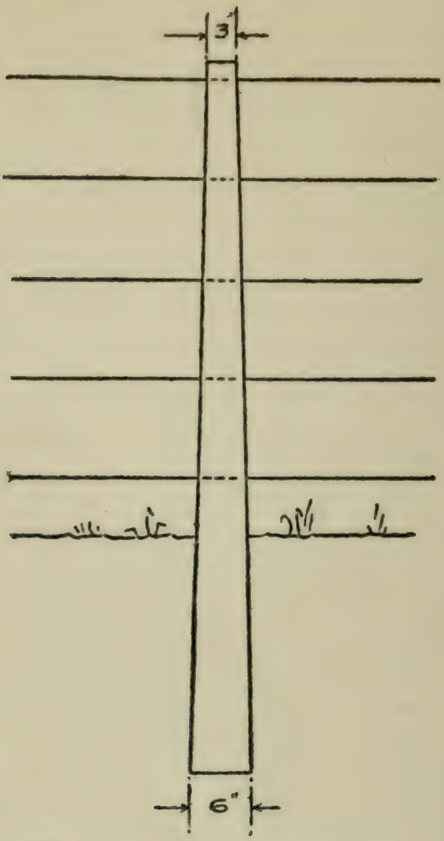


Fig. 109.—Plain concrete post.

a more modern method, perhaps—with due respectful apology to the types that have gone before.

BUILD FOR PERMANENCE

The purpose for which a fence and its enclosure are to be used is the foremost consideration, and when this is known and the requirements are determined, we too frequently proceed with the erection of the material nearest at hand, or that which is uppermost in our minds, without due regard for its permanence or appearance. Nothing deteriorates faster than many of the old-fashioned styles of fencing, and nothing will enhance or detract from the appearance of a farm more than fencing; it is the finishing touch, the trim, the frame, so to speak, of the property; hence we owe it to ourselves to make it as attractive as possible; not necessarily ornate, but unobtrusive.

A neatly painted or freshly whitewashed board fence is attractive, and some of the old-fashioned varieties with their large, square ornamental posts surmounted by urns were masterpieces in architectural design; but they were not durable, neither are they any longer an inexpensive fence. When a picket fence ages, it becomes dilapidated and shabby very quickly, and nothing is more troublesome to repair. The same may be said of cedar, cypress, and chestnut fence posts; they make excellent posts for ten or fifteen years, but unless they may be cut on the premises they are no longer obtainable at low prices, and, after all, what is a period of ten or fifteen years toward the lifetime of a farm that may stand for several generations.

A fence, or at least the posts, which usually represent the most expensive part of a utility fence, should be designed with the same idea of permanence as the farm buildings, and this may be accomplished with steel and concrete construction at a small additional cost over wood fences. Fifty years ago the idea of a concrete telegraph pole would have been considered an hallucination; yet today we find them universally adopted by railroads and other public service corporations, whose engineers have come to realize that replacing wood poles every few years is an excessive and uncalled for maintenance charge.

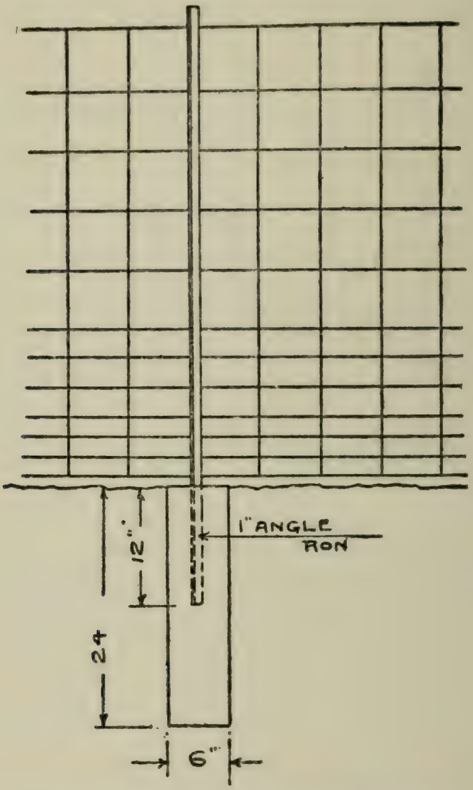


Fig. 110.—Steel and concrete post.

Because of the saving in weight, steel construction, either fabricated or in tubular form, is frequently found more practicable than solid concrete; but the base or foundation, that which deteriorates quickest, is built of concrete. The same general idea may be carried out for farm purposes by anyone with the most ordinary mechanical ability and experience, and with the aid of very few tools.

COST OF CONCRETE POSTS

The cost of a cast concrete post as shown in Fig. 109, including all materials—a good grade of Portland cement at $1.30 per barrel, sand at 75 cents per ton, gravel, pebbles, or cinders at 85 cents per ton, and the necessary reinforcement at 2 cents per pound—is 20 cents each. Where large numbers are to be made, this price will be lessened accordingly. Moreover, on the majority of farms either sand, pebbles, or broken stone is available on the premises, hence the cost will be lowered still further. The cost of a steel and concrete post as shown in Fig. 110, which is cast in a mold, will run about 18 cents each, applying the same scale of prices for material

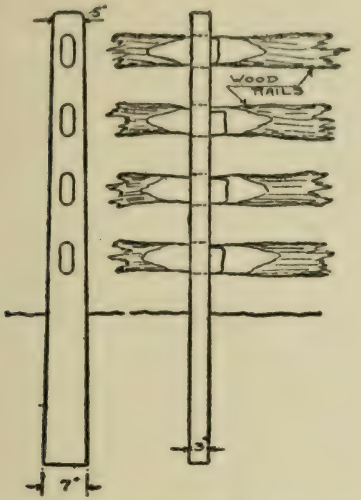


Fig. 111.—Concrete post for wooden rails.

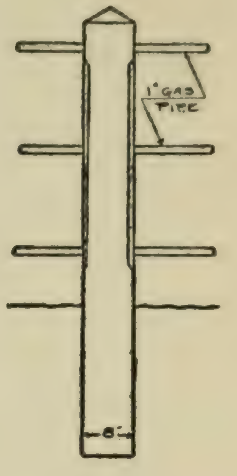


Fig. 112.—Concrete post for pipe railing.

as for the concrete post, but the labor is a trifle less. The cost of a post as shown in Figs. 111, 112, and 113 will run somewhat higher by reason of an increase in the quantity of material, and they may be made as ornamental as desired.

It is impossible to compare the foregoing prices of concrete or concrete and steel posts with wood posts, because the latter have no fixed commercial value. We do know, however, that cedar and chestnut are getting scarce, and that comparatively few posts are now put on the market merely as a by-product—the offal from a section that is being cleared for agricultural or industrial purposes. On the contrary, they are now cut and sold the same as lumber, and in the vicinity of New York, Boston, and Philadelphia the prices range from 10 to 30 cents each, depending upon the quality and the amount of freight and handling charges.

USE GROUND FOR A FORM

The erection of a concrete post may involve a little more labor, by reason of the increased weight, otherwise the *planting* process is similar to wood posts. In a clay soil, or where a clean excavation may be made with a post hole digger or earth auger, it is not necessary to first cast the steel post as shown in Fig. 110, and then plant it. Simply dig a neat hole about 6 inches in diameter and of the required depth, fill it up with a concrete mixture, and before this cement grouting has set, insert the steel angle and brace it temporarily in the proper upright position.

The post should be allowed to stand six or seven days before attaching the fence, and thereafter it will be as rigid and permanent as it is possible to get any fence post. The entire operation may be done in less than twenty minutes by one man. Later, after the fencing is hung, the iron posts should be brushed free of any rust or dirt and given one or two coats of a good grade of metallic paint.

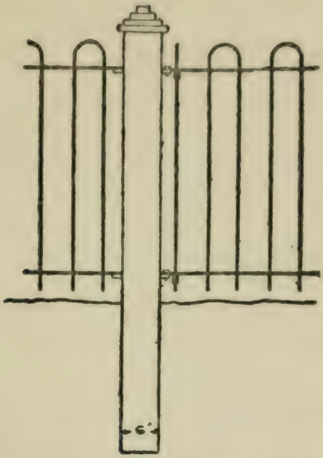


Fig. 113.—Concrete post with hairpin railing.

SECURING FENCING TO POSTS

The method of securing the fencing to the posts will depend upon the type used—four or five bars of plain galvanized wire, woven wire, or barbed wire. In all cases the angles should be punched with the necessary holes, about $\frac{3}{16}$ inch in diameter and properly spaced, before they are erected; and this is easily done with a lever punch, a contrivance similar to a leather punch, which may be purchased at a small cost or borrowed from a local blacksmith.

If plain wire is to be used, it is a very simple matter to run the various bars through holes punched in the transverse web of the angle and stretch them at the terminal points of the fences. This method relieves the intermediate posts of all lateral strains; they act solely as a bearing, and the tension is taken up by the corner posts, which are properly braced as shown in sketch. Where woven wire is used, as shown in Fig. 110, barbed wire, or types that cannot be passed through the $\frac{3}{16}$-inch holes, they should be secured to the posts by a twisted wire clip, and these clips should act merely as guides for the horizontal bars of the fencing, not grip them firmly enough to take any pull or tension. Wire stretchers of some sort are essential, especially with woven wire fencing, and these may be borrowed from the manufacturers of fencing, as an accommodation to their customers.

MOLDS FOR POSTS

The forms or molds for casting concrete posts may be built of inch lumber, properly braced and stiffened to prevent warping, using additional members wherever ornamentation is desired. The concrete should be mixed in the following proportion: 1 part cement, 2 parts clean, sharp sand, 4 parts pebbles, broken stone, cinders, or slag. No reinforcement is necessary in the heavier posts as shown in Figs. 112 and 113; whereas it would be advisable to use a couple of $\frac{1}{4}$-inch iron rods in the lighter posts, and particularly those that exceed 6 feet in length. These may be embedded in the concrete as it is poured, care being taken that they do not settle to the bottom of the mold. Concrete sets up very quickly in warm weather, and while it is safe to remove the form in forty-eight hours or less, the posts should be subjected to no serious strains until they have cured for about two weeks. In cold weather twice the time is required, and in no case should concrete be used in a temperature below 30° F.

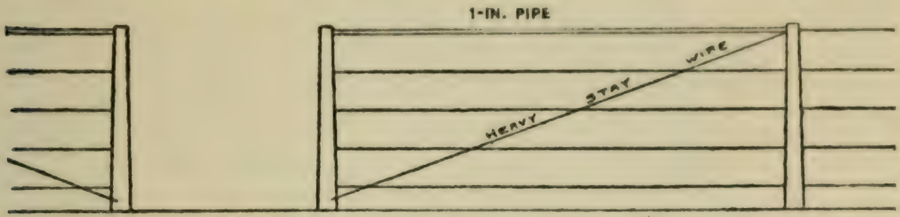


Fig. 114.—Method of bracing corner posts.

CASTING HOLES IN POSTS

Where the fencing is to be made of single strands of wire in conjunction with concrete posts, as shown in Fig. 109, provision must be made for holes in the posts at the time they are cast. Insert 40-penny (5-inch) wire nails in the concrete, and remove them as soon as the initial set takes place, but before the cement has hardened and bonded with the nails. A good way to simplify this work and also to obtain uniform intervals for the wire, is to insert the required number of nails in a batten properly laid off, then with a single operation the nails may be embedded, and, later, removed and the same batten used repeatedly. If barbed wire is to be hung, woven wire as shown in Fig. 110, or any other form of fencing that will not pass through small holes, means should be provided to insert some fastening or purchase for the wire clips as described for the angle iron posts. Ordinary fence staples with their ends

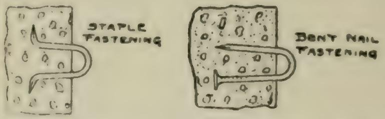


Fig. 115.—Simple types of fastenings for wire fencing.

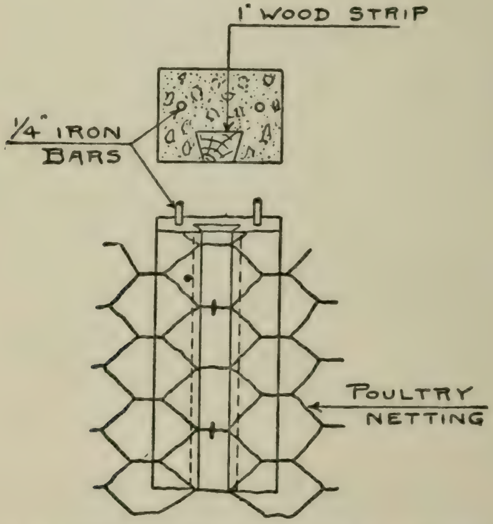


Fig. 116.—Method of inserting wooden ground in concrete post for securing poultry netting.

slightly twisted to form an anchor, or 10-penny (3-inch) wire nails bent like a hairpin, may be inserted in the concrete as shown in Fig. 115. This is too troublesome in the case of poultry netting, where many fastenings are required, and a nailing ground should be substituted: a 1-inch strip of wood, bevelled as shown in Fig. 116, embedded in the concrete when it is poured. The strip will remain perfectly secure, and to this the netting may be fastened with staples as on a wood post.

WOODEN RAILS WITH CONCRETE POSTS

On farms that were formerly fenced with split rails, either the old-fashioned *worm fence* or a fence similar to Fig. 111, and where probably the rails are in fair condition but the posts have rotted away, it will be found economical to replace the decayed wooden posts with concrete, and utilize the rails as before; in which case the concrete post may be cast as a replica of the wooden post. In this way a permanent fence may replace the derelict fence at approximately the same cost of repairs.

The post of Fig. 112 is strong and substantial looking, an example of ornate simplicity which is very easy to obtain in concrete, and the design is suitable for lawns or estates where something of a more pretentious character is desired. The rails are of 1-inch gas or water pipe, either galvanized or black iron, painted, and form a type of fence that is virtually indestructible. The holes in the post to receive the pipe should be made ⅛ inch greater in diameter than the pipe, and obtained in a manner similar to the nail-holes previously mentioned. It is important, however, to have the holes accurately lined and parallel, otherwise it will be difficult to screw together the various lengths of pipe.

Figure 113 is commonly known as a "hairpin" fence, and is very neat and attractive when used in combination with concrete posts. It is more expensive than the other types, and suggests the unlimited possibilities of concrete and wrought iron. The "hairpin" sections may be purchased in stock sizes at about 15 cents a running foot; whereupon it is only necessary to cast proper anchors or lugs in the posts to receive them.

DEVICE FOR SECURING WIRE

Figure 117 illustrates a simple, inexpensive device for securing the ends of heavy wire, instead of splicing, which is usually rather troublesome and unsightly.

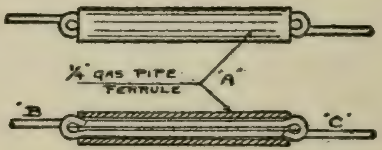


Fig. 117.—Inexpensive device for splicing ends of heavy wire

The ferrule or sleeve "A" is cut in 2- or 3-inch lengths from ¼-inch, inside diameter, galvanized iron gas or water pipe, through which both ends of the wire "B" and "C" are inserted. The ends of the wire are then bent with a pair of pliers as shown, and when drawn taut jam themselves into the ends of the ferrule, thereby forming a perfect hitch. The cost of these ferrules should not exceed 8 cents a dozen.

CHAPTER XII

CONCRETE WATERING TROUGH

IT is needless to emphasize the importance of an abundant supply of clean water for the livestock—one might as well deprive an animal of feed as to neglect this necessity. Furthermore, there are sentimental and ethical reasons. It is so gratifying to watch a team of horses refresh their parched throats after a day's work in the hot, dusty fields, that to offer them other than a cool, pure drink from a clean receptacle seems, somehow, to be unkind, inhospitable, and grossly ungrateful. The horse is a fastidious eater and drinker—admirable characteristics—hence to offer him something that his master would disdain is in the nature of an insult.

Discarded, slime-covered tubs and sawed-off barrels are shambling watering devices at best, and if one has not carefully selected cedar or cypress planks with which to construct a well-made wooden trough, they are apt to be leaky, makeshift looking affairs, and without sufficient durability to warrant the original labor. Concrete costs very little more than the material for a good wooden trough; it is easily kept clean, and when properly constructed it is everlasting. The design for such a trough is shown in the adjoining pages, and it is so simple in its construction that anyone with the ability to handle a hatchet and saw and build a rough form can execute a satisfactory job. The trough is made fairly heavy, note Fig. 118, on a concrete foundation to prevent damage by frost action; there is no economy in trying to save a bag or two of cement. The entire

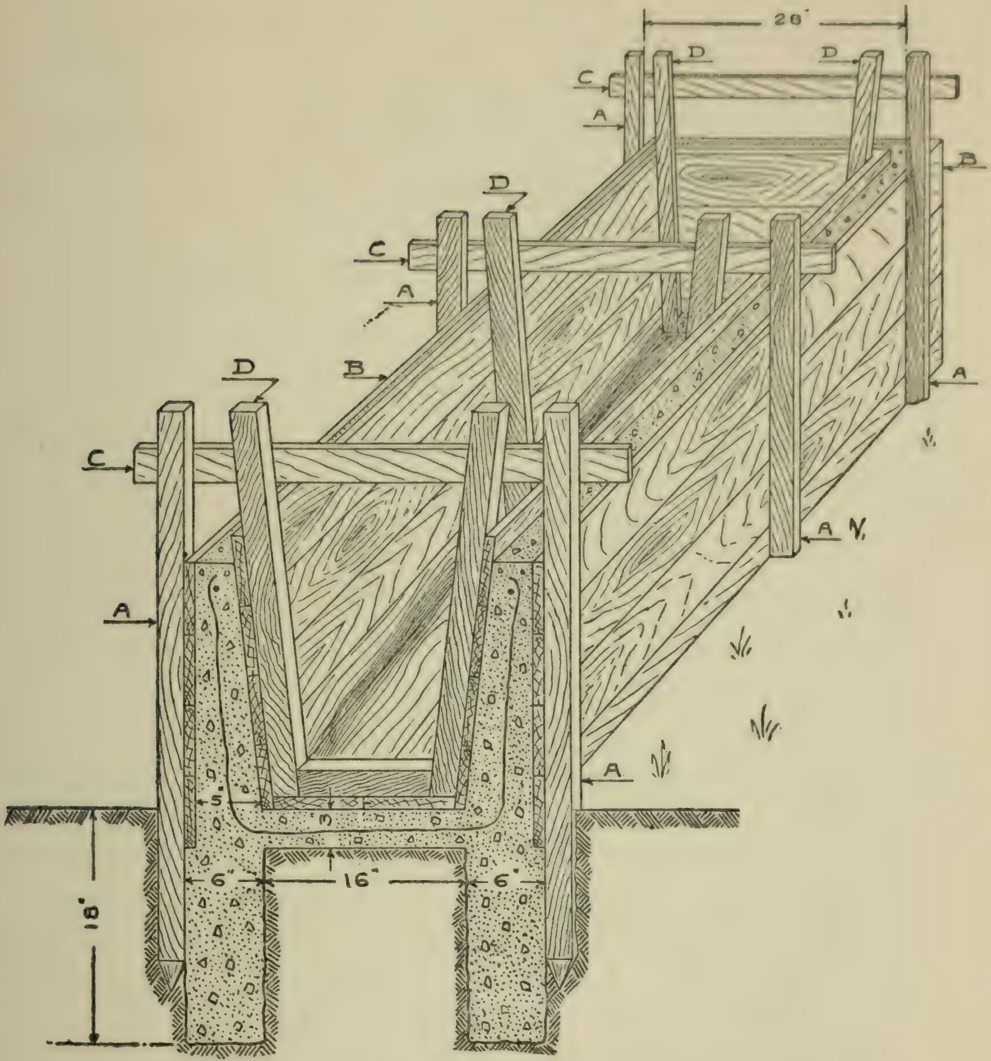


Fig. 118.—General view of concrete watering trough.

trough and its foundation is cast in one continuous operation. If the excavation is neatly and accurately dug, the earth will answer for a mold instead of wooden forms below ground level. Much of the work may be done in the shop or on the barn floor on a rainy day, for the only involved piece of construction is the interior form.

ERECT TROUGH IN ITS PERMANENT POSITION

Select a site that is level, or nearly so, in the most convenient location for the trough, and drive six stakes (A), preferably of 2 x 3 inch material pointed at one end and about 4 feet long, firmly into the ground in the form of a rectangle as shown in Fig. 118. The distance between the inner edges of the stakes (A) should be 28 inches, and the intervals between them to suit the desired length of the trough, which is figured 6 feet in the sketch. At a point 19 inches above the ground line nail the form boards (B) of inch lumber, which will later become the finished edge of the trough, therefore they must be level. When the structure has thus become rigid, commence the excavation, which is best made by a square-edged garden spade; remove the soil and trim its sides to the proper depths, after which the boards (B) are carried slightly below the ground line. If a solid foundation is not found at 18 inches below grade, dig deeper until such is obtained.

The inner form is substantially made from the same material as the outer form. It is, in reality, a rectangular box with sloping sides and ends and a flat bottom, 4 inches narrower at the bottom than at the top, 4 inches shorter at the bottom, and about 21 inches deep. The braces (C) are nailed to the posts (D), and are later nailed to the stakes (A), when the inner form is placed in its final position, which is not done, however, until the concrete foundations and floor slab have been poured, and the reinforcement is inserted.

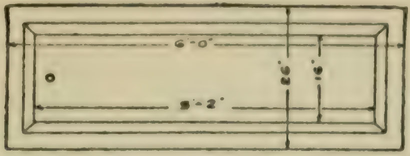


Fig. 119.—Plan of watering trough.

OVERFLOW AND DRAIN

The trough is fitted with an overflow and drain, as shown in Fig. 120, also it may be equipped with an inlet or hydrant connection for the supply. Inch galvanized pipe will answer the purpose nicely, which must be inserted in its proper position before the concrete is poured. The 18-inch length of pipe in the interior of the trough should not be screwed into the coupling any tighter than may be removed with the hands without the aid of a wrench, and the upper edge of the coupling should be about flush with the finished level of the trough, so that it will act as a drain for cleaning purposes when the overflow pipe is unscrewed. To facilitate cleaning the bottom of the trough should be slightly pitched toward the outlet—½-inch drop is sufficient.

When the foundations are poured and the floor slab has been brought half-way to its full depth, embed the woven wire reinforcement—1-inch mesh poultry netting will do—as shown in sectional diagram; then insert and nail the interior form in its proper position, and continue pouring the concrete. A little tamping with a spade will force the concrete underneath the interior form so as to prevent any voids, and when the pouring operation is brought to within 3 inches of the top of the trough, embed a ⅜-inch horizontal rod around all four sides, which will impart the necessary tensile strength

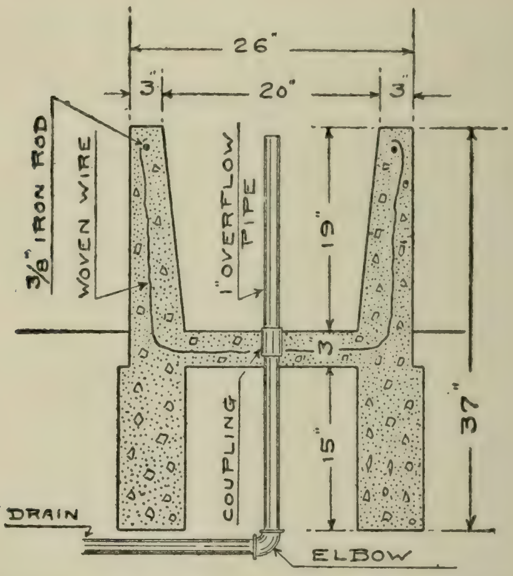


Fig. 120.—Cross-section of trough, showing the foundation cast in one operation.

to the rim. Clip off the wire netting slightly below the finished surface, and then complete pouring the concrete. Later, when the concrete has set hard enough for the forms to be removed, and while it is yet green, the surface should be trowelled to a smooth "sidewalk" texture with a 1 : 2 mixture of cement and sand. Two weeks should elapse before the trough is subjected to the weight of the water, and even then it will spall and fracture very easily should it receive a severe blow. Six months and sometimes a year is required to thoroughly cure concrete so it will not spall.

The following is a list of the materials required for the concrete for a trough as herewith illustrated, and they should not exceed a cost of $4.00.

20 cubic feet of broken stones or pebbles.
10 cubic feet of clean, sharp sand.
5 bags or 1¼ barrels of cement.

The lumber for the forms will probably be secured from odds and ends lying about the farm buildings; or, if purchased for the trough, it may be used again for other purposes.

CHAPTER XIII

REPLACING DEFECTIVE FOUNDATIONS WITH CONCRETE

GENERALLY speaking, our forefathers had better material with which to construct the frame portions of barns and other farm buildings than it is possible to obtain today except at prohibitive prices, and in consequence many of these old structures are almost as sound and weather-proof as the day they were built. That is, they are sound above the foundations, but seldom secure below the sills, owing to the inferior materials then available. In old buildings most foundation walls were made of rubble masonry—undressed field stone, either laid up dry, or with a lime-and-sand mortar that frequently soon crumbled and fell out—leaving the greater part of the strength of the wall dependent upon the weight of the building to bond the stones together.

Builders of today, though they may not have the framing timbers nor the sun-seasoned shingles and siding of their forbears to put into the superstructure, are more fortunate in having better materials for the foundations. Thus, an interesting comparison is to be made between the depreciation of farm buildings erected fifty or sixty years ago and those built in the last two decades. The more modern buildings usually deteriorate from the roof downward, whereas the old structures decay from the ground upward.

Wood usually fails first at the ground, because it receives the greatest moisture and the least air at that point; as soon as decay sets in the structure settles and deviates from the perpendicular, and this settlement and deviation thrusts unequal strains on the foundations, causing them to bulge and slide from their original position.

Farm sheds are often supported on posts—with or without sills—blocked up with loose stones. Weeds grow around the base of the shed, or manure is piled against the walls, confining the moisture, and the bottoms of the posts soon rot away; in time the building is askew or maybe it will collapse. Drainage from the stable floor is also very hard on barn sills, especially if the floor is located close to the ground where there is insufficient ventilation, as is usuallythe case with old barns.

Once the sills decay or the foundations start to crumble the building is doomed to a gradual racking and disintegration, unless steps are taken to remedy the defects. We are reminded, perhaps, that "the creaking gate hangs long on its hinges"; nevertheless, it is better economy to renew or strengthen defective foundations at the earliest opportunity, when it can be accomplished at comparatively small cost and little labor. Many otherwise derelict outbuildings have been saved in this manner.

Concrete is the best material with which to make these repairs, not only because it is the easiest to handle for any purpose, large or small, and because it is durable and inexpensive, but because a first-class job can be done by the farmer, with the help of his own farm labor, at odd times when the crops are not claiming his attention. No outlay for tools is necessary, for it so happens that the tools needed for concrete construction are the very ones every farmer uses for every-day work—

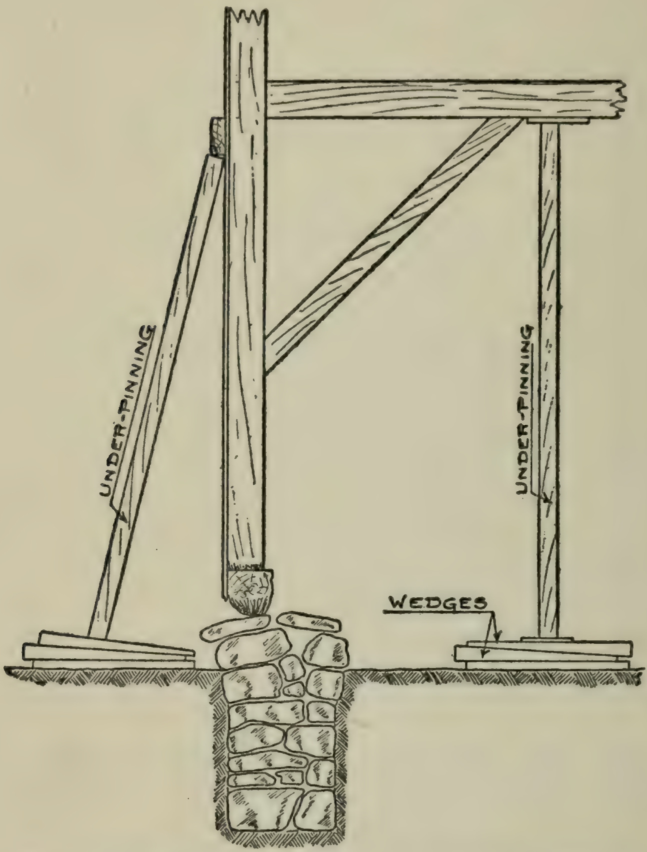


Fig. 121.—Temporary shoring to support building.

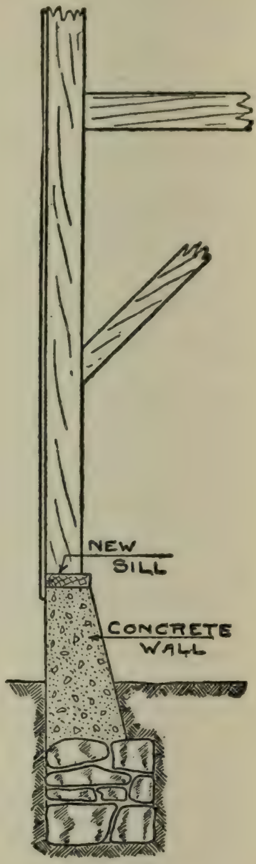


Fig. 122.

shovels, hoe or rake, wheelbarrow, water barrel, water buckets, and a tamper or rammer.

Being plastic, concrete takes the shape of anything against which or in which it is placed, and almost any material that will hold the concrete in place will do for a form. Below ground earth walls are usually firm enough to act as a form; above ground the forms will have to be made of wood. Plan the forms so there will be no difficult measurements to remember, and make them strong enough to hold the concrete without bulging out of shape. Endeavor to use as few pieces of lumber as possible, and do not drive them full of unnecessary nails. If forms are to be used only once, as is generally the case on the farm, they should not be nailed so securely as to prevent their being taken apart without splitting, and the lumber used for something else. A good plan is to drive the nails with their heads projecting far enough to be caught by a claw hammer and readily removed.

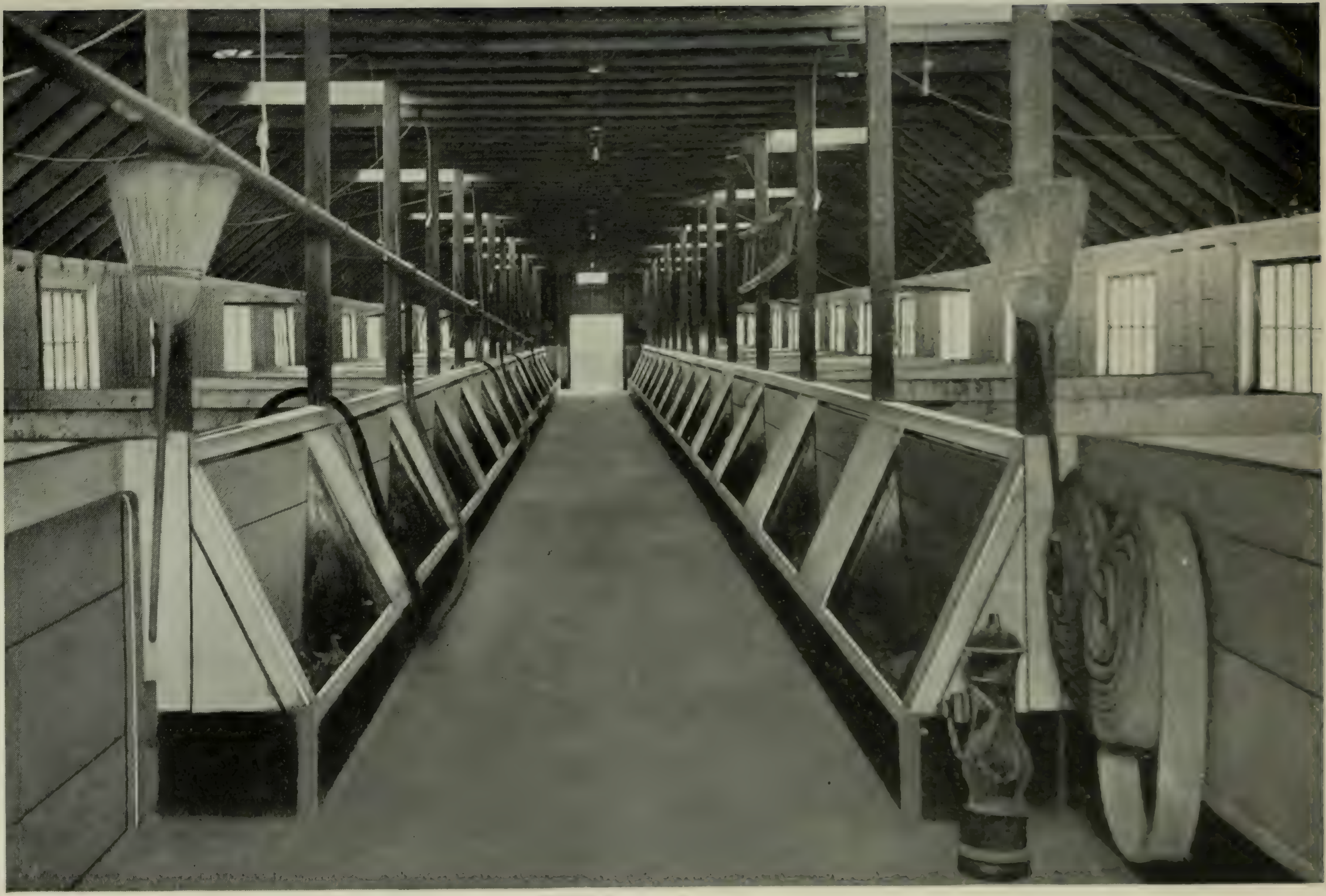
UNDERPINNING THE STRUCTURE

If the posts or sills of a building are badly rotted away, or the foundations have crumbled and been displaced so as to cause settlement, it is usually better to take the old sills and loose portions of the foundations out entirely and build a concrete wall up to the proper height to take their places. To do this, first support the building by temporary struts alongside of the posts to be removed, as shown in Fig. 121. A couple of jackscrews will be a great convenience in erecting this underpinning or shoring, but if these are not available, since farm buildings are usually not very heavy, this work may be done very nicely by the use of wedges, as shown in diagram.

At the same time the building is underpinned it should be elevated so as to straighten and correct any settlement. When this is done, and the operator is assured that the underpinning is securely held, saw off the posts above the rotten part and cut away the sills and other defective material; also remove any loose stones in the masonry, even though it may be necessary to take out the greater part of the old foundation wall. Next, set in place the forms for the concrete, and have them extend to the level of the new sill, which is not put in place until after the concrete is poured, thus affording plenty of room for this work.

The bottom of the wall should be about 15 or 18 inches thick, and made larger than the top, which narrows to 10 or 12 inches, by simply sloping one side of the box form, giving the effect shown in Fig. 122. Leave the forms in place for one week, and after two weeks, when the concrete should be thoroughly hard, and after the new sill has been inserted, remove the struts which have been used as temporary support for the building.

Every farmer must use his own judgment in placing the concrete in the forms; the important thing to re-



Interior of an up-to-date hog house; pens and floor of concrete

member is that as little time as possible should elapse between the "mixing" and the "placing." Furthermore, the work on each section should be poured as much as possible in a continuous operation, and the concrete must not be disturbed after it has taken its initial set; to do so will impair its strength. After the concrete is in the form it should be tamped lightly with a wooden or iron tamper or rammer until the water shows on the top and no stones are left uncovered by the mortar. If new concrete is poured on old work, the surface of the old work must be thoroughly cleaned of any oily or vegetable matter in order to insure a perfect bond. It is also advisable to wet the surface of the old work.

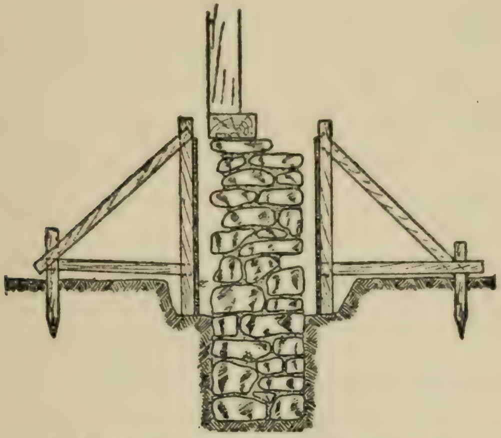


Fig. 123.—Forms for strengthening a crumbled wall or foundation.

STRENGTHENING A CRUMBLED WALL

Sometimes the stone foundations of a building are in a badly weathered or crumbled state, but not weakened to the point of causing settlement, and perhaps the sills and other framework are in a perfect state of preservation. If exposed to the weather much longer such walls are almost certain to disintegrate and collapse. On the other hand, conditions do not seem to warrant underpinning the building and replacing the old foundation with a new concrete wall. Instead, the old masonry may be strengthened and dressed with a facing of concrete, and thus made as strong—and stronger—than its original construction.

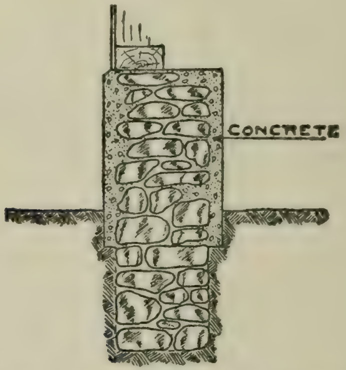


Fig. 124.—Repaired wall, with old masonry carefully bonded together.

On either side of the wall, and about 3 inches from the normal face of the masonry, erect forms as shown in Fig. 123. Fill these spaces with a fairly wet mixture of concrete, so that all voids in the old masonry are thoroughly bonded together, as shown in Fig. 124. Tamp the concrete until it comes up flush with the bottom of the sill, to the entire width of the wall, and after it has become fairly hard the outer edge may be beveled to act as a water table.

The forms for this work should be built in sections, and moved from place to place as the work progresses. The concrete should be mixed with small stones or pebbles, preferably ¾-inch material, so that they may enter the crevices and holes in the masonry.

CHAPTER XIV

WORK-BENCH AND TOOL CABINET ARE VALUABLE AIDS

THE difficulties of carpentering work and troublesome little repair jobs are greatly reduced where there is a suitable place to work upon, together with a few simple appliances to facilitate the use of tools. Freedom of movement is essential, of course, and good lighting, but the most important of all is a firm foundation—a strong, heavy work-bench that will withstand pounding, pushing, and pulling without corresponding vibration or wobble.

The diagram in Fig. 125 illustrates a practical design for a work-bench—inexpensive, durable, and simple to construct. The selection of material will depend upon the kinds of lumber that prevail in various localities, and are the most economical; although it should be fairly hard, free from loose knots or cracks, and well seasoned. Spruce, yellow pine, birch, chestnut, or ash will do very nicely; and while poplar, white pine, cedar, or cypress may be used, they are really too soft to endure the wear and tear that the bench will receive. On the other hand, hemlock, while hard enough, is too brittle and will splinter. The bench may be built as a table independent of the wall, but it will require more material, and then, too, it will not be as rigid and secure as when made a part of the building.

Six feet is a convenient length for the average work-bench, and while it may be made any width, 3 feet will be found none too wide when it is necessary to lay out a large piece of work. To erect the bench, first cut a piece of 2 x 4,—6 feet long, and securely nail it to the wall 28 inches from the floor in the location previously selected for the best lighting. In front of a window is the

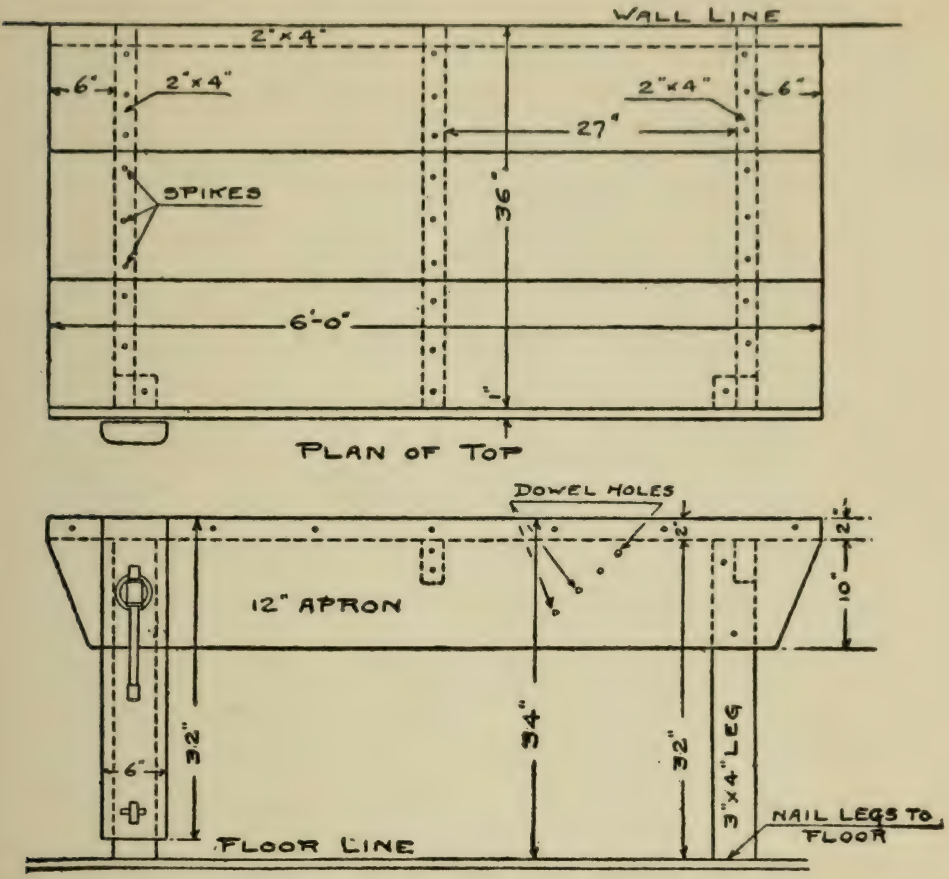


Fig. 125.—Plans for a simple durable work-bench.

most desirable place. Cut three cross-pieces of the same material 36 inches long, and two pieces of 3 x 4, 32 inches long for legs. Nail the end cross-pieces and legs 6 inches in from the ends of the bench, as shown on diagram; omit the center cross-piece until the apron is erected, and then nail it in place. The apron should be

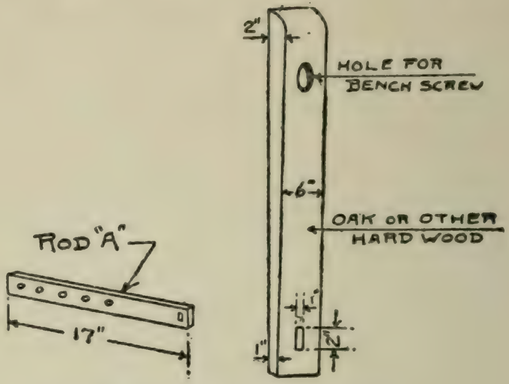


Fig. 126.—Details of vice.

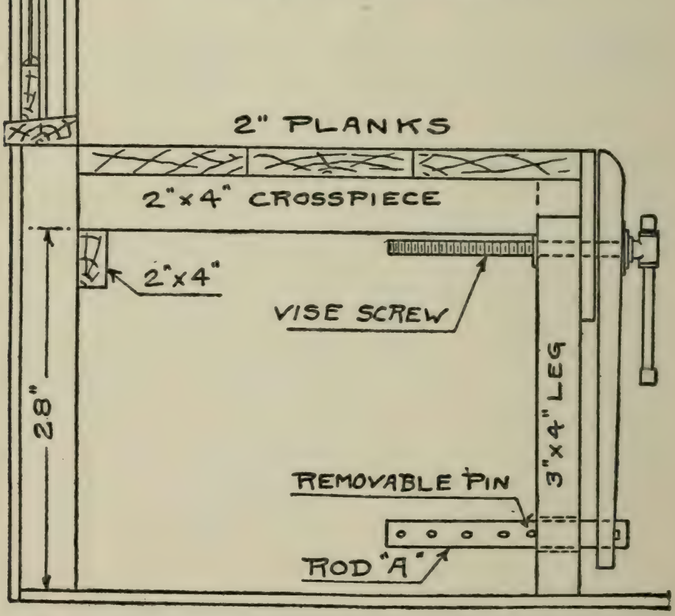


Fig. 127.—Cross-section of bench in way of window.

a well selected 12-inch board cut as shown, and made to extend flush with the top surface of the bench. The top consists of three 12-inch planks, 2 inches thick, spiked into the cross-pieces, and extreme care should be taken that all nails are punched below the surface to avoid damage to edged tools. If the planks are much thinner than this, when pounding on them the work will bounce.

VISE OR BENCH SCREW

It is quite necessary to have a vise or bench screw, and one may be purchased for about 75 cents. The jaw, as shown in Fig. 127, should be made of oak or other hard wood, 6 inches wide and 32 inches long, 2 inches thick at the top and tapered to 1 inch at the bottom. In the center of the jaw, about 7 inches from the top, bore a hole slightly larger than the vise screw, also a mortise at the bottom of the jaw, as shown in Fig. 126. Assemble the screw and its fittings according to the manufacturers' directions, which usually accompany an article of this kind; insert the equalizing rod "A" which serves to guide the bottom of the jaw and travels parallel with the screw, and the bench vise is complete. The rod "A" should be drilled with ½-inch holes at intervals of about 2 inches, and fitted with a removable pin.

The uses and advantages of a vise are numerous, and some of them will cause considerable wear on the inside faces of the jaws. Perhaps it will be necessary to clamp bolts or metal work in the vise, and for rough usage of this kind a pair of sheet-iron jaws should be used. Note Fig. 128. They are easily made, and will prolong the life of a wood vise indefinitely. No need to fasten them, rather have them handy to insert for temporary use.

For planing and work that requires a board to be held on edge, and where it is impractical to use the vise, a bench stop, as shown in Fig. 129, will be found very convenient. Use a fairly hard piece of wood about 1 inch thick, and cut a V-shaped slot in it the long way of the grain; nail it securely to the extreme left-hand corner of the bench, where it will be of the most service, and yet out of the way of ordinary work. This is known as a "bird's mouth" stop; there are others, some of them patented articles which are embedded in the top of the bench. For light work, a screw or nail head projecting slightly above the surface of the planks is equally serviceable.

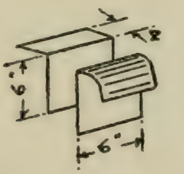


Fig. 128—Metal jaws for wooden vise.

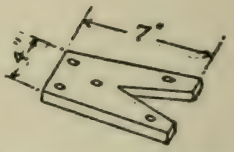


Fig. 129.—Bench stop.

When long boards are to be held in the vise it is advisable to support them at the right-hand end of the bench. Bore three or four ¾-inch holes in the apron at varying heights, as shown in Fig. 125, and fit them with a wooden dowel pin which may be removed and adjusted as desired.

TOOL CABINET

A corner in the barn or wagon-shed, designated as a work-shop, with a place for every tool and every tool

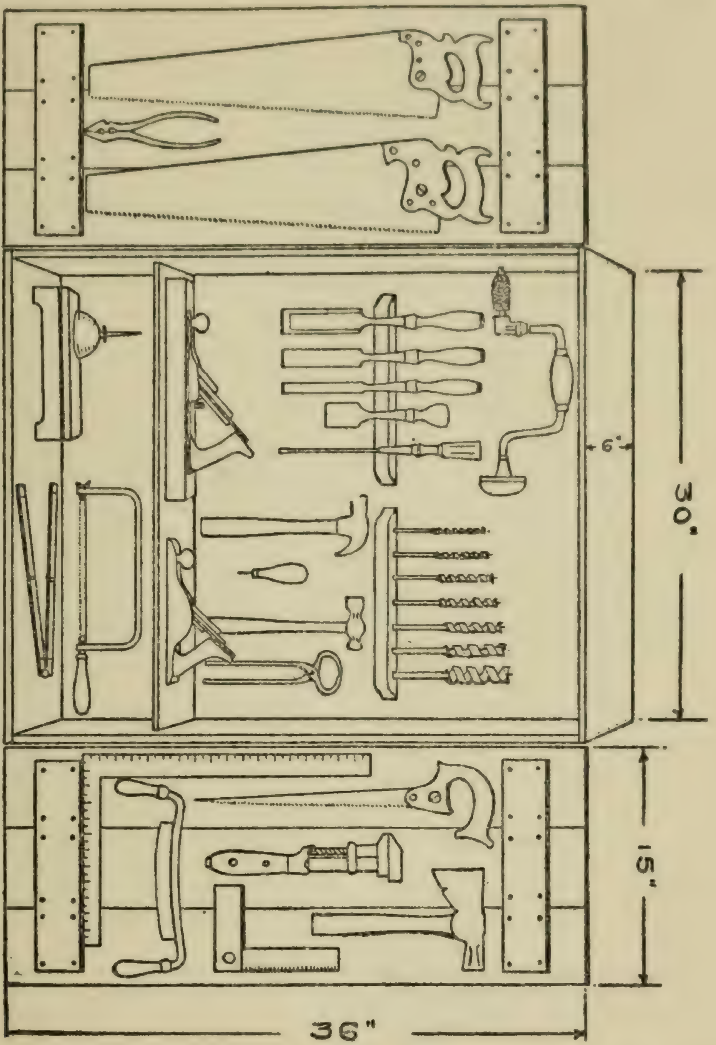


Fig. 130.—Tool cabinet, so arranged that all the tools are offered to view.

restored to its place, is a valuable asset on the farm, and will save many a vexatious situation when something breaks or goes awry and must be repaired in a hurry. If a $\frac{3}{8}$-inch auger bit is wanted to bore a hole for a clevis bolt, or the king pin of a waiting team requires a nut tightened, there is seldom time to search among the boxes and odds and ends of the outbuildings for the necessary misplaced tools. It were better and less strain on one's patience if this important part of a farm's equipment were assembled in an appropriate place and available for instant use.

A tool cabinet located at the back of a work-bench, and so arranged that all tools are offered to view and easily accessible, is a convenience well worth the few hours required to make it. Such a cabinet is shown in Fig. 130, and may be constructed of $\frac{1}{2}$-inch square-edge siding, or packing box material that is not too hard and brittle. It is, in reality, a box 36 inches high, 30 inches wide, and 6 inches deep, which is large enough to accommodate the average set of wood-working tools. The front consists of two doors hinged at either side, and used for storing the saws, squares, and so on, in the manner shown. Racks similar to Fig. 132 should be made for the bits and chisels, and screwed to the back of the cabinet; the planes, oil-stone, block, and oil can stand on shelves; and the other tools hang on brass cup hooks or nails driven into the back or sides of the cabinet as desired.

The shelf should be made about 4 inches wide, which will allow 2 inches clearance for the tools on the doors when the cabinet is closed. Figure 131 illustrates a simple device for supporting the saws: the block "A" is cut to fit the hand hole in the saw handle, using a piece of closely grained wood slightly thicker than the saw, which is secured to the cabinet door by two flat-head screws as shown. The button "B" is then fastened to the block "A" by a round-head screw, with sufficient freedom for the button to turn in a transverse position.

Neater work will be the result if 6-penny finishing nails—2-inch wire nails with small heads—are used throughout, and the cabinet is sand-papered and given a coat of shellac or hard oil. A lock or hasp will add to its security, and may, perhaps, command the respect that tools should receive.

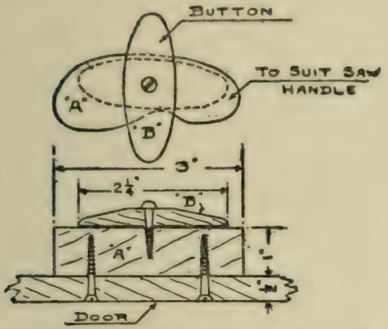


Fig. 131.—Simple device for securing the saw.

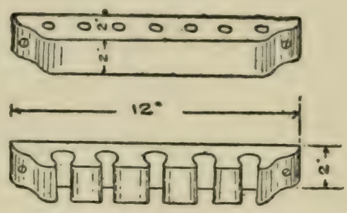


Fig. 132.—Racks for holding auger bits and chisels.

Twenty-four square feet of ½-inch lumber is required to build the cabinet, allowing for waste. A special stowage place for every tool acts as a checking system. When a job is completed a glance at the cabinet will indicate if any tools are missing.

CHAPTER XV

POWER DERIVED FROM ROPES AND PULLEYS

A TACKLE, sometimes called a block and fall, is an assemblage of blocks and ropes, arranged as a system of pulleys, whereby great power is gained for moving or raising heavy weights through a simple mechanical principle. Beyond this casual observation we seldom give any serious thought to its vast potentiality; yet, like the lever, the tackle is one of the most powerful agencies at our command, and has probably figured more prominently in the world's industrial development than any other mechanical device. It is the first consideration in shipbuilding, in the erection of tall buildings, bridges, mining, transportation, and power transmission—in fact, every other mechanical undertaking and achievement. Without the tackle's extraordinary broad adaptability the most powerful engine or motor would be virtually helpless to transmit its energy.

The tackle is not only invaluable in an engineering capacity, but of great assistance in the most commonplace forms of endeavor, as, for example, farm work—in which it is frequently necessary for the farmer to exert more energy than is humanly possible, and where it is not feasible to use horse power. Perhaps there is hay to be lifted to the mow, a tree to be pulled down, stumps drawn, a building to be moved, wire fencing to be stretched, an engine or heavy piece of machinery must be unloaded from freight car to wagon, and the wagon subsequently unloaded at the farm; these and many other every-day occurrences require the use of tackle in some form or other, which will be reviewed in this chapter and described with as little technical matter as possible.

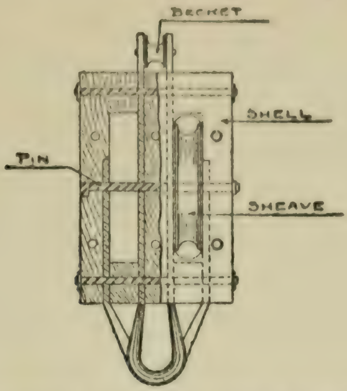


Fig. 133.—Diagram showing parts of a block or pulley.

CONSTRUCTION OF BLOCKS

Blocks are mechanical contrivances possessing the properties of pulleys, usually constructed of steel or hard wood, and consist of four principal parts: the shell or outside, the sheave or wheel over which the rope turns, the pin or axle on which the sheave revolves, and the strap, either rope or metal, which encircles the shell and by which it is confined or secured to a particular purchase.

Wooden blocks are known as made or mortised, the term "made" being applied to those which are assembled from several parts, and the term "mortised" applied to those which are hewn from a single piece of wood and mortised to receive the sheave. Blocks take their name from the purposes to which they are applied, or from some peculiarity of form, and are said to be single, double, treble or threefold, and fourfold, according to the number of sheaves they contain. A snatch block is always single and fitted with a swivel hook that may be unclamped to receive the bight of a rope, thereby avoiding the necessity for running the end of a rope through the sheave hole. When a tackle has been drawn so close together that the blocks jam and cease to operate, it is termed "two blocks." Drawing the blocks apart is known as "fleeting" or "overhauling the purchase." All blocks should be examined at regular intervals for any serious wear on the straps and pins. The sheave on which the hauling part of the rope works receives the most wear, hence in blocks of more than one sheave it is a good plan to alternate this working sheave with the least active one. The thimble or becket is the metal ring suspended from the end of the block opposite the hook, and to this the "standing" or fixed part of the "fall" is secured. The word "fall" is the term applied to the rope; the rope and blocks together form the tackle.

MOVABLE BLOCK

In working with tackles of any kind it must be remembered that the tension on the rope is the same throughout, from the hauling part to the end fastened to the becket—friction not considered. Also that no gain in power is made by stationary blocks, since they serve merely as a lead for the fall, whereas all increase of power is derived from the movable blocks. With due allowance for friction, which will be discussed in another paragraph, the total increased power to be gained by a tackle is equal to the number of parts of the fall at the movable block. Obviously, the block having the greatest number of parts of the fall should be secured to the object to be moved, wherever possible, in order to gain the greatest mechanical advantage. It is not always practicable nor convenient to do this, however, as in lifting a weight from the ground, in which case the upper block is the hauling block, and will therefore have the greatest number of parts.

KINDS OF TACKLES AND THEIR POWER

The simplest form of tackle is that shown in Fig, 134, commonly known as a single whip or girtline, and consists of a rope rove through a single stationary block. A convenient lead is obtained in this manner, but no power is gained by it. In fact, there is a small decrease in power due to friction. When the arrangement is inverted, as shown in Fig. 135, and the block is attached to the weight, twice the power is gained. To gain twice the power with an overhead lead, two single blocks must be arranged, as in Fig. 136. Three times the power can be gained by two single blocks if the hauling is done from the movable block, as shown in Fig. 137, whereas to accomplish the same power with an overhead lead, a double and a single are necessary, as shown in Fig. 138. The same general rule applies to tackles of still greater power, which will be noted by an examination of the other diagrams.

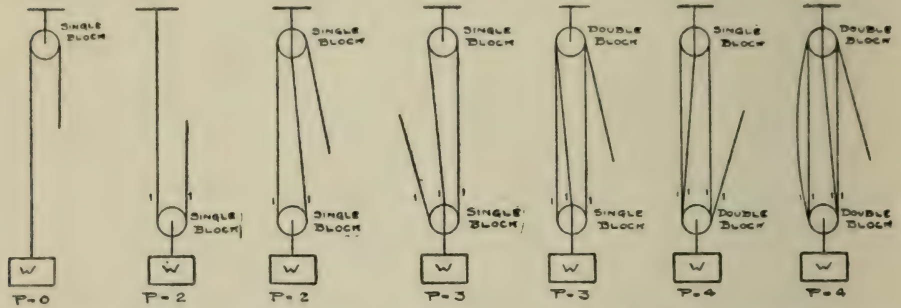


Fig. 134. Fig. 135. Fig. 136. Fig. 137. Fig. 138. Fig. 139. Fig. 140.

Figs. 134–140.—Power gained by pulleys.

A strong man may grasp an object in his hands and lift a weight much greater than his own; but no matter how strong this man may be he cannot raise more than his own weight with a single whip tackle. If he weighs 180 pounds, a 180-pound weight attached to the tackle will produce a balance or equilibrium.

TACKLE REQUIRED FOR A GIVEN WEIGHT

To determine the power required to raise a given weight, divide the weight in pounds by the number of parts of the fall at the movable block, and the result or quotient will represent the power necessary to produce an equilibrium, friction not included. If it is a one-man operation, and the quotient or equilibrium is greater than the man's weight, the hoist will not be accomplished for reasons in the foregoing paragraph, and either more men must be summoned to the task or the tackle must be increased. Example: A stone weighing 600 pounds must be loaded on a wagon by one man whose weight is 150 pounds; and a tackle as shown in Fig. 140—two double blocks—is contemplated to perform the task. The tackle cannot be reversed, as shown in Fig. 141, because an overhead lead or haul is required; consequently, since the number of parts at the movable block in Fig. 140 is four, 4 is divided into 600 pounds and the quotient is 150 pounds, the exact weight of the man—with no allowance for friction. If two treble blocks are substituted, as shown in Fig. 144, the number of parts at the movable block is 6; divided into 600 pounds it will amount to 100 pounds,

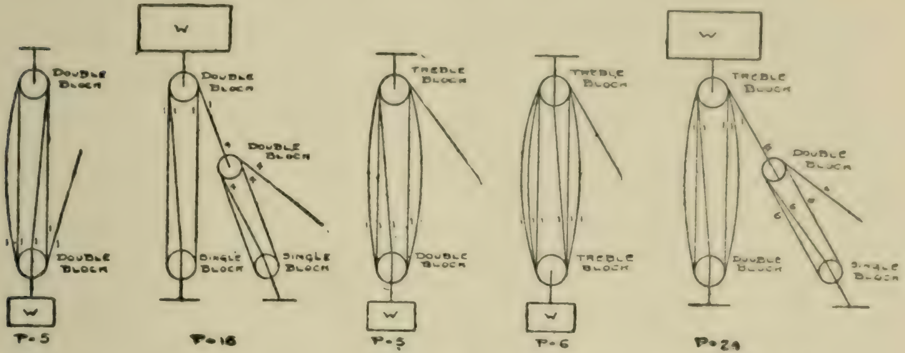


Fig. 141. Fig. 142. Fig. 143. Fig. 144. Fig. 145.

Figs. 141–145.—Power gained by pulleys.

which it is possible for one man to haul. A more practicable arrangement, however, would be to employ three men on the tackle first considered, Fig. 140, whereby each man would be required to haul 50 pounds plus one-third the total amount of friction.

FRICTION—OR LOST ENERGY

Experiments and tests have demonstrated that 15 per cent. or about one-sixth the original hauling power is lost or taken up by friction every time the fall passes round a sheave. Thus, in Fig. 140, a twofold tackle containing four sheaves, if the hauling tension is 60 pounds, one-sixth of 60, or 10 pounds, is lost on each sheave, 40 pounds is lost on the four sheaves and must be subtracted from the total power of the tackle, 240 pounds, which leaves a working margin of 200 pounds. Friction is lightened or increased by the condition of the blocks, the size of the sheaves, and the relation of the rope to the sheave. Wherever possible use large blocks and small ropes, for light rope is more pliable than heavy cordage. Never work a rope so large for the block that it binds or chafes the sides of the mortises. It not only wears out both fall and block, but greatly increases the friction.

With a specific or limited power at one's disposal, to ascertain the amount of tackle or purchase to raise a given weight, first consider and eliminate the amount of friction, then divide the weight by the power, and the result will constitute the number of parts of the fall to be incorporated in the movable block attached to the weight. Example: A 400-pound cask must be raised by a man capable of hauling 120 pounds. One-sixth of this hauling power, or 20 pounds, is allowed for friction; the remaining 100 pounds divided into 400 pounds will give 4 as the number of parts of the fall at the movable block. On consulting the diagrams, Fig. 140 is the arrangement to be used for raising the cask, whereas an object of equal weight may be hauled in a horizontal position by a single and double block tackle, as shown in Fig. 139.

SAFE LOADS FOR TACKLES

To determine the greatest weight to which tackle may be subjected—all other factors, the hooks, straps and lashings, being duly considered—multiply the greatest tension a single part of the fall may safely endure by the number of parts at the movable block. Example: The breaking strain of ¾-inch diameter Manila rope is about 2 tons, but since the safe load for cordage of any kind is considered to be about one-third the breaking strength, 1400 pounds may be borne by a single part of a ¾-inch fall. Thus, with four parts at the movable block, as shown in Fig. 140, such a tackle would be capable of lifting four times 1400 pounds, or 5600 pounds—close to 3 tons.

If one tackle is secured to the hauling part of another tackle, or what is termed "luff upon luff," note Fig. 142, the power transmitted to each part of the second tackle is equal to the total power of the first tackle. In other words, multiply the number of parts at the movable block of the second tackle by the number of parts at the movable block of the first tackle. Thus, in Fig. 142, the smaller tackle consists of a single and double block which has four parts at the movable block, and when multiplied by the four parts at the movable block of the larger tackle the total is 16. Figure 145 illustrates a similar arrangement with a threefold purchase on the large tackle, and the total power is 24. Another "luff tackle" secured to the hauling part of the second tackle would give an increase of 24 x 4, or 96 times the original power, and so on. These rules, of course, are subject to a reduction for friction, which is very considerable in a multiplicity of tackles.

It must be remembered, however, that while enormous power can be gained by a series of tackles, it is also obtained at the expense of time and an inconvenient accumulation of fall. In view thereof, it is frequently more economical to employ greater hauling power in the first instance, as, for example, a donkey engine, winch, or windlass.

An interesting demonstration of the principle of a tackle will be found in rolling a barrel up an incline or skidway with the loops of two rope ends. A heavy cask is to be loaded into a wagon from the ground: Incline two planks at the tailboard, secure the center of a 50-

foot piece of rope to the front axle or other suitable place, leading both ends over the seat, back along the bottom of the wagon, and down the inclined planks to the ground. Roll the cask over the ropes, which should be spaced about 2 feet apart and the rope ends returned over the cask to the floor of the wagon. From this position an equal pull on both rope ends will roll the cask up the incline with very little effort expended. The rolling of the barrel corresponds to the rotary action of the sheave in the block, and the rope ends to the fall of a tackle, as shown in Fig. 135, wherein twice the power is gained.

DERRICKS

The three kinds of derricks used for ordinary work are shown in the accompanying sketches: A straight pole derrick, as shown in Fig. 146, commonly known as a "gin pole"; the "A-derrick" or shears, Fig. 147; and the "jib derrick" or crane, Fig. 148. The gin pole is the

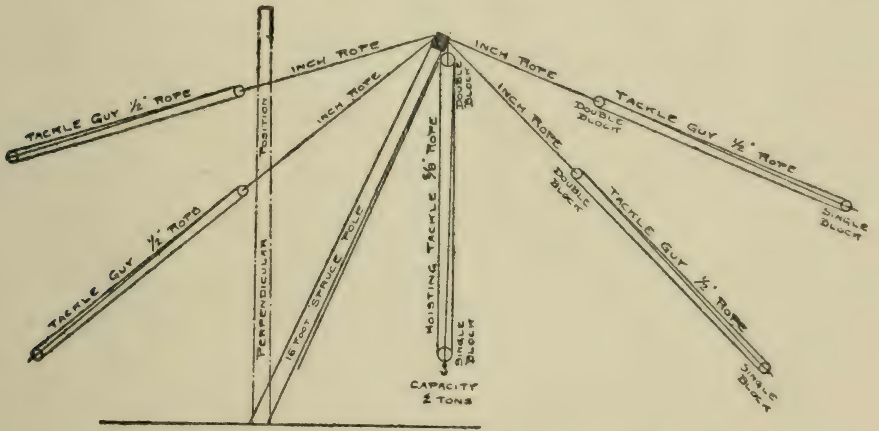
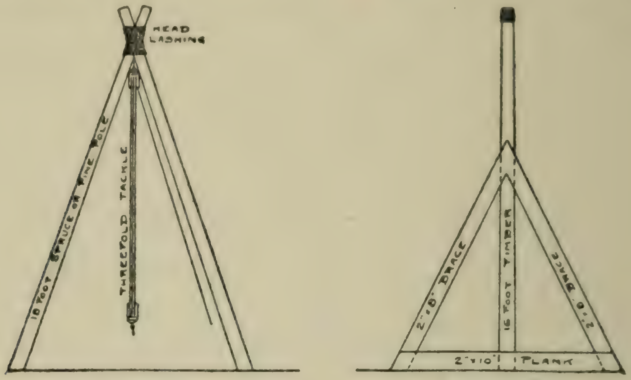


Fig. 146.—Simple derrick or "gin pole."

most generally used, especially for temporary work. It is easy to transport, simple to erect, and when braced with four guys the "head" may be "raked" or swung at any angle for depositing a weight at a given point. The A-derrick or shears may be made to sustain very heavy loads, and is generally used for hoisting objects clear of the side of a building or pier, or where the object is particularly cumbersome—such as a flag-pole—and must be straddled by the derrick. It is used aboard ship for erecting masts. The jib derrick is in



Shears. A-derrick.

Fig. 147.—Two types of derricks.

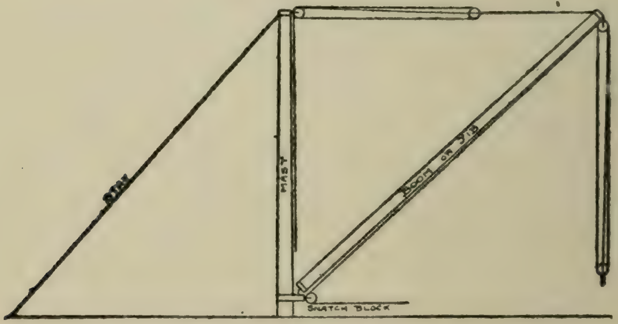


Fig. 148.—"Jib derrick," or crane.

the nature of a permanent crane, a very convenient contrivance for loading and unloading from one conveyance to another, as at a railroad siding or a wharf, and where bulky objects may be swung clear at the end of a boom or jib and deposited at a considerable distance from the hoisting point.

So many mechanical principles, calculations, and other factors enter into the design and proportion of a derrick when determining its ultimate strength that it is impossible to establish even a comprehensive rule for their exact sizes. The length of a timber in relation to its diameter, the angle from a perpendicular position, and the variety and quality of the wood must all be taken into consideration. For the average hoisting work on a farm, which does not exceed 2 tons, a clear-grained spruce spar 16 feet long and 6 inches at its narrowest diameter is amply strong; and with it use $\frac{5}{8}$-inch diameter rope over the hoisting tackle and $\frac{1}{2}$-inch diameter rope on the tackles for guys. For 5-ton work

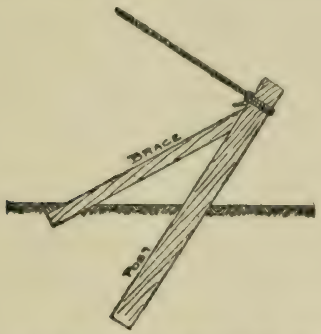
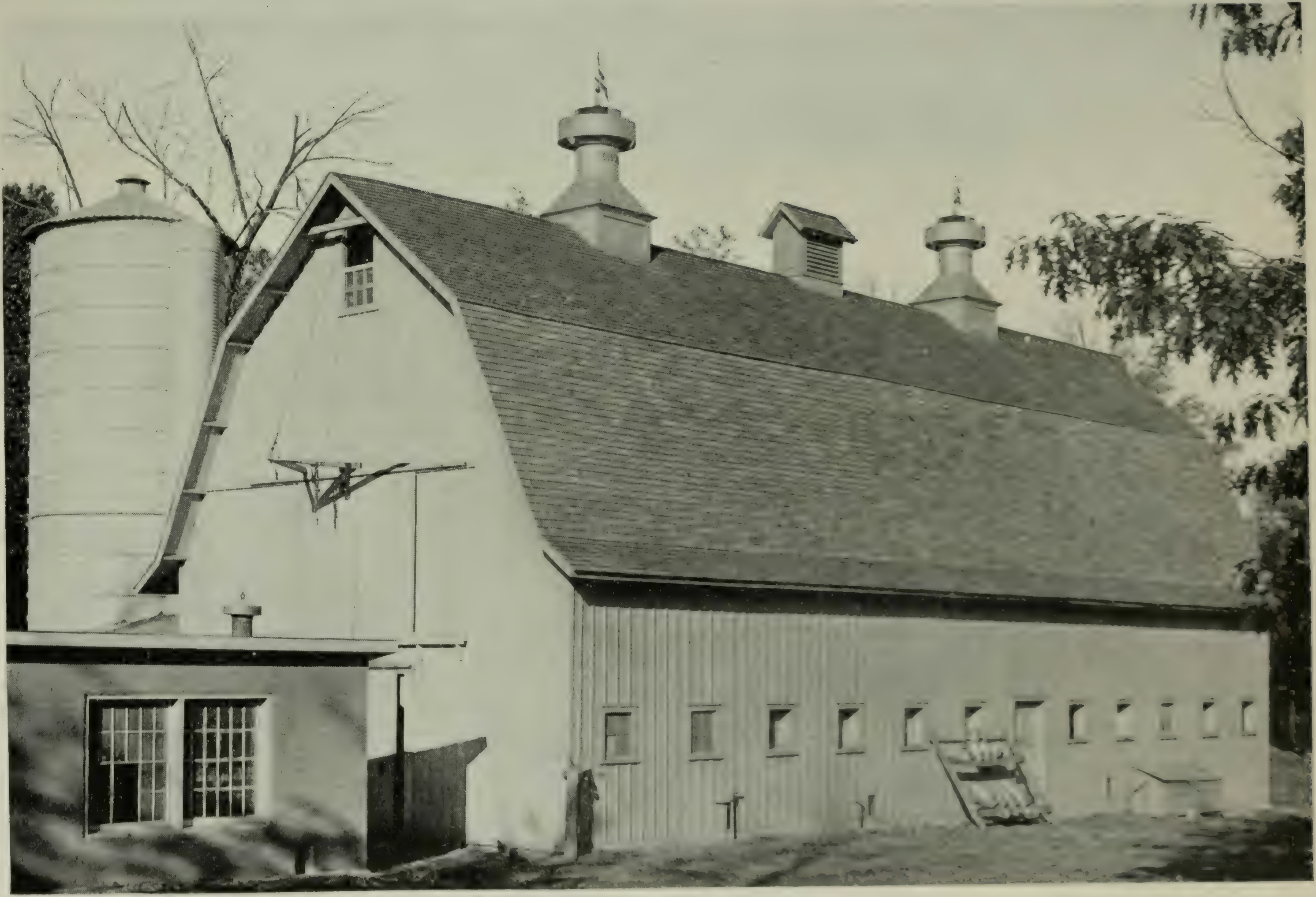


Fig. 149.—Post planted in ground to serve as lashing, commonly called a "dead man."

use an 8-inch spar, inch rope on the hoisting tackle, and $\frac{5}{8}$-inch on the guys.

In setting up a gin pole care should be taken that the foot of the derrick is securely braced, so that when the head is raked at a wide angle from the perpendicular the foot will not "kick" up nor slip. The guys—at least three and preferably four—should be led to points as nearly equidistant as possible and securely fastened. If tree butts or other suitable lashing purchases are not available, put down a post as shown in Fig. 149, commonly called a "dead man."



Eighty-foot general farm barn; concrete hennery on the left

CHAPTER XVI

PLANS OF FARM BUILDINGS

THERE are three important elements in the construction of a *cellar for storing vegetables and roots:* the interior should be reasonably dry, antifreezing, and with sufficient ventilation to prevent mustiness. Artificial heat would cause undue evaporation, therefore it is customary to build the cellar below ground level on well-drained soil. If building stone is available on the premises or obtainable nearby it may be used economically; otherwise it might be well to consider concrete or hollow tile.

The accompanying sketch, see Fig. 150, illustrates a 12 x 20 feet cellar 8 feet deep with 16-inch masonry walls; whereas, if concrete is substituted, the walls need only be 8 inches thick. The excavation may be made the full depth of the cellar, to correspond with the existing grade level; or it may be dug about 6 feet deep, and with the soil that is removed throw up an embankment or terrace around the building. Very often it will be convenient to select a location on the side of a hill, and thereby minimize the amount of excavating. If the site is on old ground and there is a uniformly firm foundation for the masonry walls, no concrete footings are necessary; otherwise it would be advisable to build them

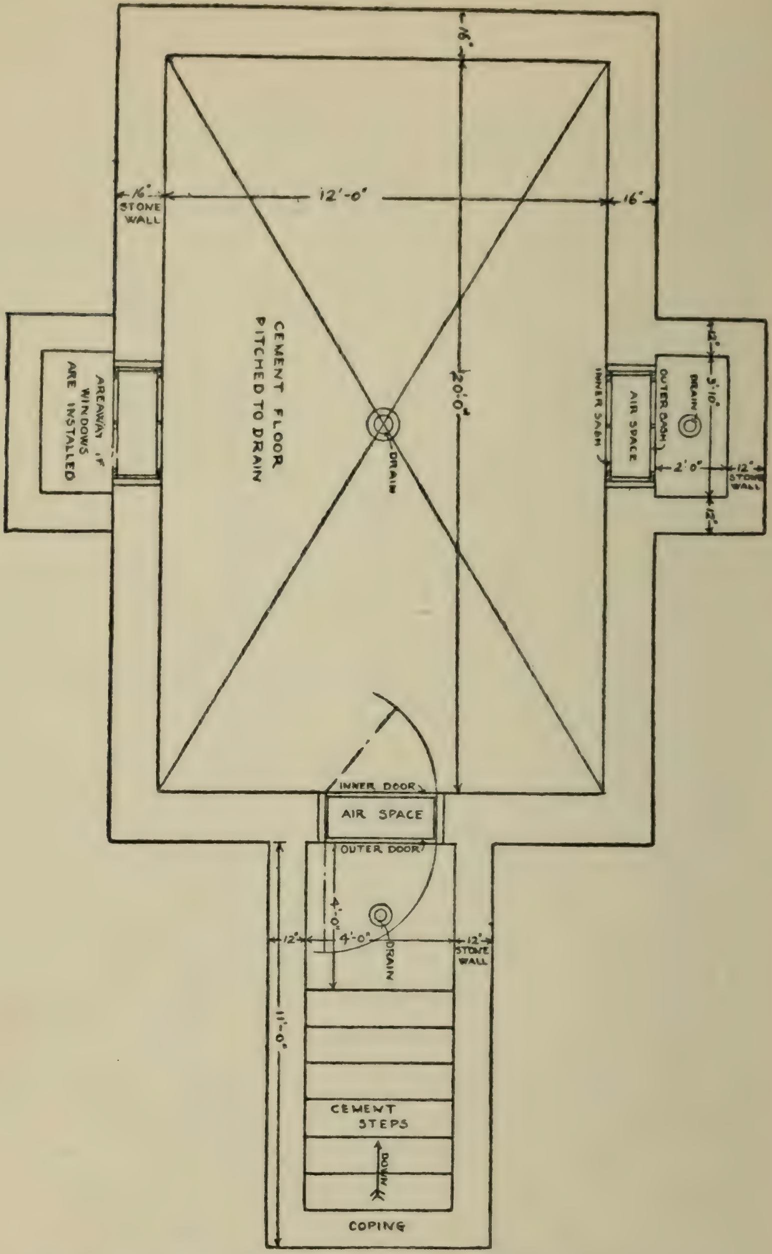


Fig. 150.—Plan of cellar for storing roots and vegetables.

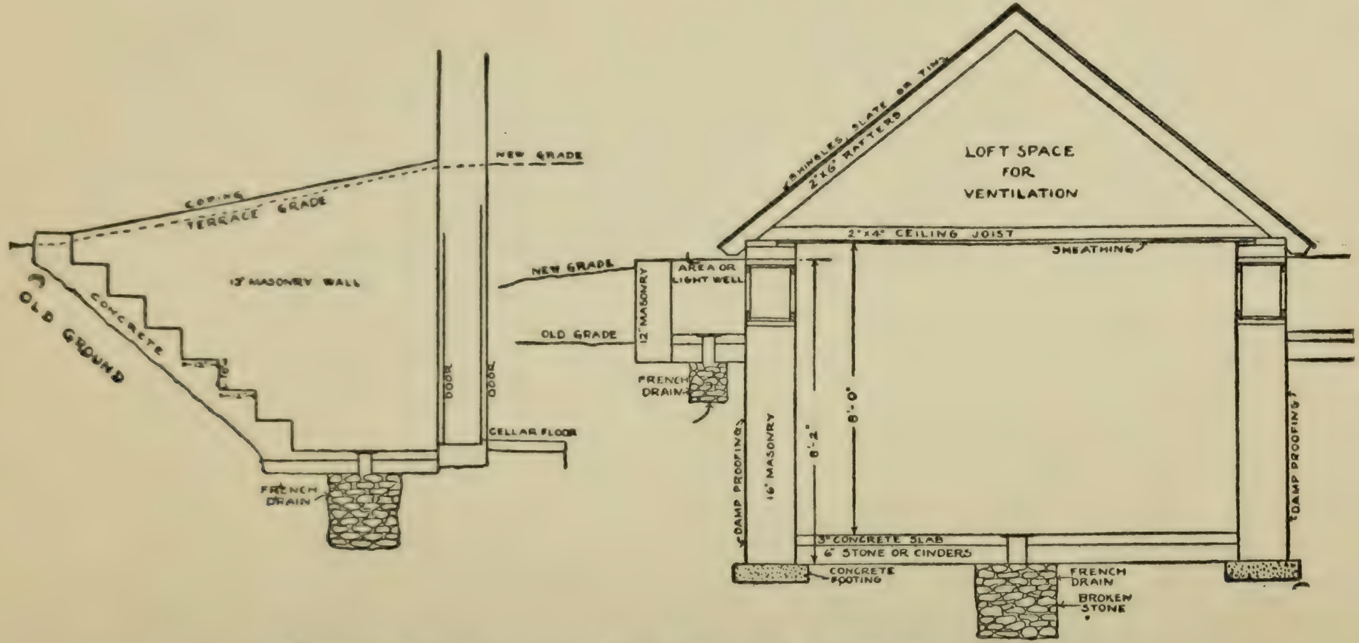


Fig. 151.—Cross-section of root cellar and detail of entrance steps.

as shown on Fig. 151. The floor should consist of 4 to 6 inches of broken stone or cinders well tamped, then covered with a 3-inch slab of concrete. The bottoms of the areaways may be finished in the same manner, or left in the rough. If finished, however, they should be provided with a French drain similar to the entrance areaway and cellar floor; remove 3 or 4 cubic feet of soil, refill with broken stone, and before the coat of finishing cement is applied insert a cast iron stable drain or grid, through which any water may run off.

If the building site is not naturally well drained and there is likelihood of moisture penetrating the stone walls, the exterior should be damp-proofed with a $\frac{1}{2}$-inch coat of cement mortar (1 part cement to 3 parts sand) mixed with water containing a waterproof solution. The inside face of the walls may be left in the rough or porridged and troweled to a smooth surface. The floor should have a finishing coat of cement, pitched to drain for cleaning purposes; likewise the entrance areaway and steps, which are built with a coping as shown on sketch, and covered with doors to exclude snow.

Windows are not essential except for the convenience of lighting the interior, and if installed they should consist of an inner and outer sash, both carefully weatherstripped; or the upper portions of the inner and outer door may be fitted with glass.

The shape and type of roof—shingles, slate, tin, and so on—is a matter of individual taste; or it may be found convenient to erect a structure over the cellar. A simple shed roof is shown in Fig. 151, with a light frame ceiling of matched boards. The loft space acts as a non-conductor and for ventilation of the cellar, obtained by cutting small vents in the ceiling, and fitting them with slides that may be opened or closed as weather conditions require. If the vegetables are stored in baskets or barrels no special interior fixtures are required; whereas, if they are stored in bulk, bins should be provided with slatted sides and bottom to keep them from coming in contact with the masonry.

CONCRETE MANURE PIT

Where manure must be stored for a considerable length of time, pits or basins are required. A good plan is to build them with a driveway or incline, up which a spreader or cart may be drawn. This slope should not be over 1 foot for every 4 feet out. To give teams a sure footing on the incline, embed in the concrete as it is poured some sort of cleats, as shown in Fig. 152.

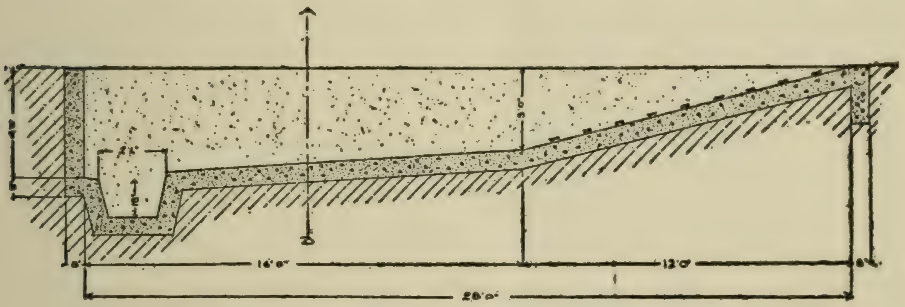


Fig. 152.—Section of a concrete manure pit.

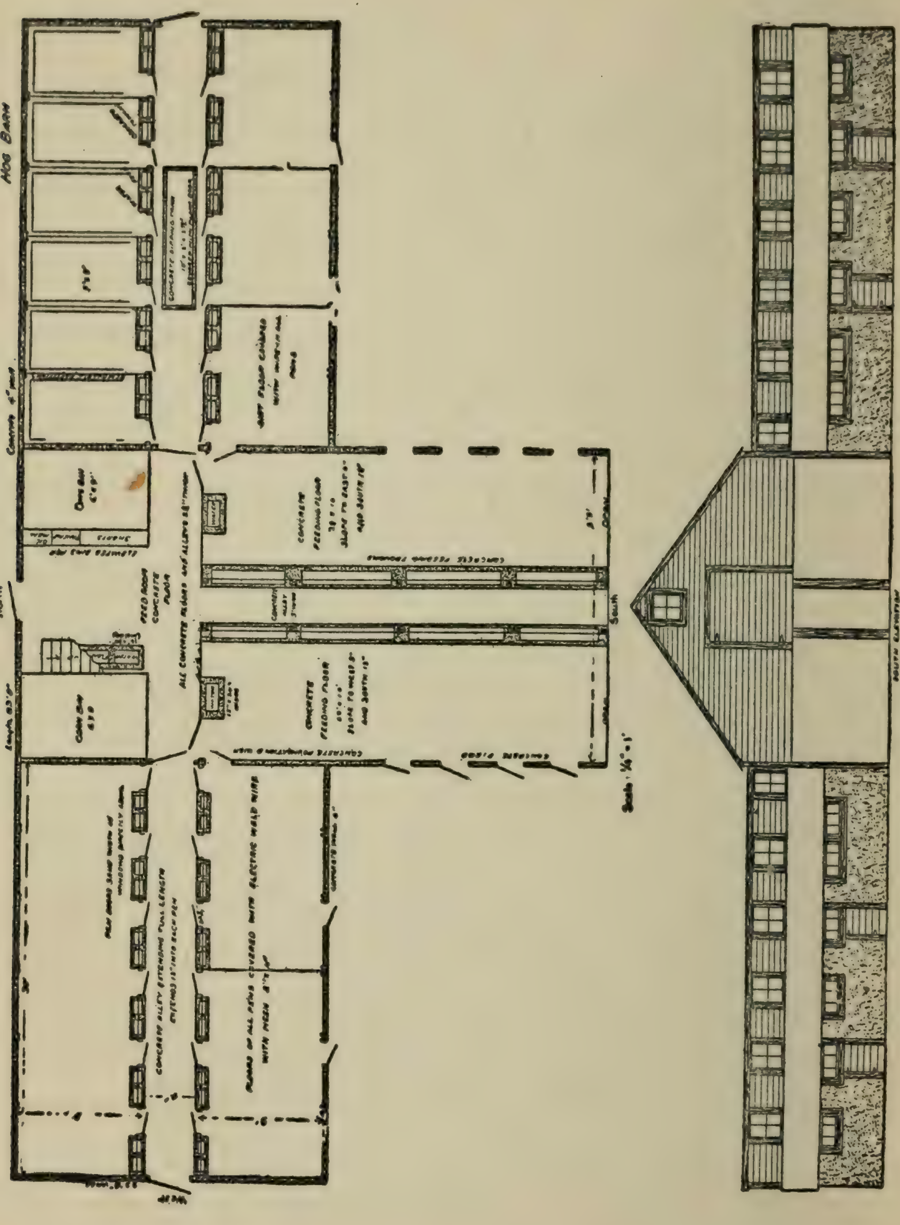


Fig. 153.—Combination hog house, with hay and grain storage rooms.

DIPPING VAT

Dipping in certain solutions has been found to be the most effective means of ridding animals of vermin, such as the cattle tick, scabies, lice, and so on. On account of its lasting qualities concrete has been found to be an excellent material for dipping vats. There are some important points to be considered in the building of a vat, as follows:

(1) A blind chute—an inclined runway, so that the animal cannot see where he is going.

(2) An entering slide, steep enough to shoot the animal in, without a full drop. A direct drop is likely to injure the animal.

(3) Vat must be narrow enough to prevent the animal from turning round, long enough to keep him in from one to two minutes, and deep enough not to force him to swim, but to make him disappear entirely when he takes the first plunge.

(4) Slope at the leaving end must be gradual and its surface roughened or cleated, so that the animal may easily climb out to the draining pens.

(5) As the liquid dip is the most expensive part of the operation, the draining pens should be fitted with a dripping tank or trough, into which the solution drains, to be used over again.

The dimensions of ground pits for dipping vats are shown in the table (p. 259), the letters at the head of each column corresponding to those shown in Fig. 154.

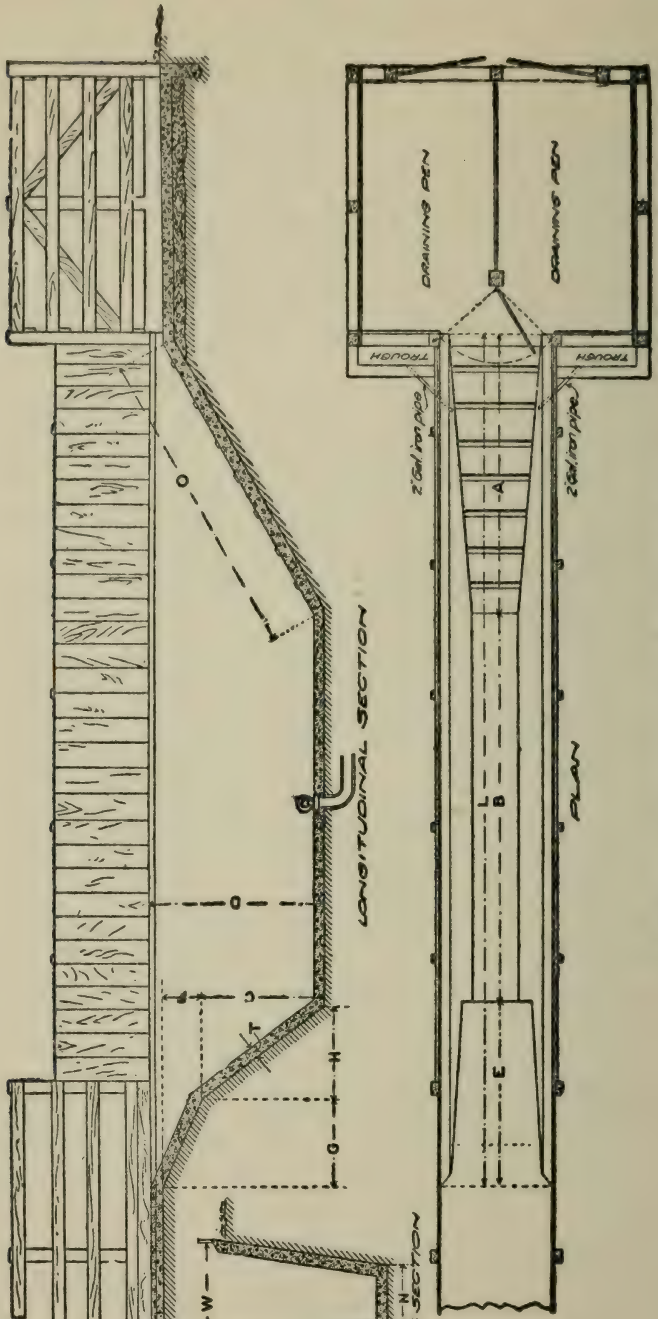


Fig. 154.—Construction of a dipping vat.

The quantities of materials required are also figured out in the last three columns of the table.

Kind.	*W*		*N*		*D*		*L*		*E*		*B*		*A*		*G*	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Horses....	5	10	3	4	8	8	55	0	7	6	31	0	16	6	3	9
Cattle.....	5	4	3	4	7	8	51	0	6	8	31	0	13	4	3	4
Sheep.....	3	4	2	4	5	8	46	0	5	0	31	0	10	0	2	6
Hogs......	3	4	2	4	5	8	36	0	5	0	21	0	10	0	2	6

Kind.	*F*		*H*		*C*		*O*		*T*	Cement.	Sand.	Rock.
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*In.*	*Bbls.*	*Cu.yds.*	*Cu.yds.*
Horses....	2	2	3	9	3	9	18	7	8	43	13	26
Cattle.....	1	11	3	4	3	4	15	4	8	37	11	22
Sheep.....	1	5	2	6	2	6	11	6	8	24	7	14
Hogs......	1	5	2	6	2	6	11	6	8	19	5½	11

BILL OF MATERIAL FOR COLONY HOUSE

(As shown in Fig. 155.)

Use.	Size. *Inches.*	No. of Pieces.	Length. *Feet.*	Board Measure. *Feet.*
Sills (runners)	4 by 6	2	12	48
Joists	2 by 4	3	14	28
Studs and braces	2 by 3	13	12	78
Rafters	2 by 4	3	16	32
Total				186
$\frac{7}{8}$-inch matched flooring (floor and sides)				340
$\frac{7}{8}$-inch sheathing surfaced one side				100
Roofing paper, 1 roll.				
Windows, hardware, etc.				

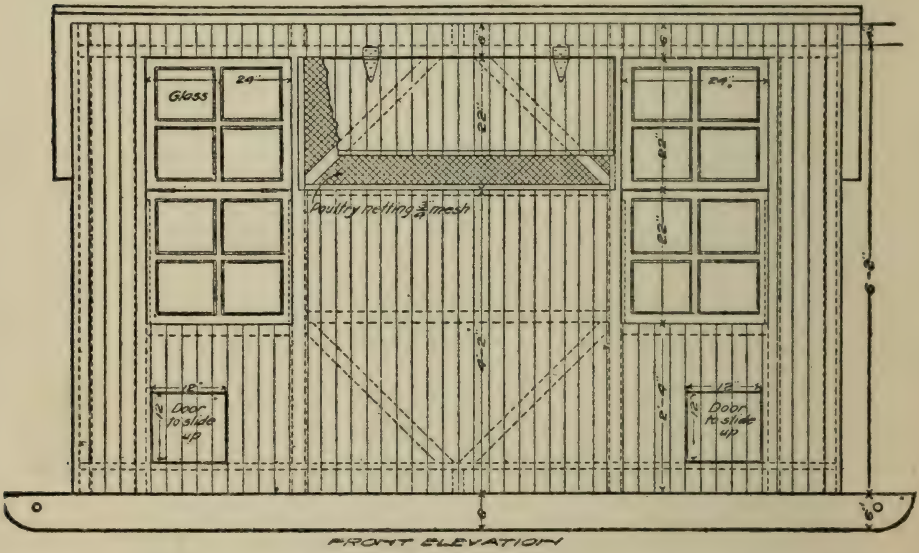


Fig. 155.—Front view of colony house used at Government Poultry Farm, Beltsville, Md. Capacity 25 hens.

NOTE.—Sills (runners), 4" x 6"; joists and rafters, 2" x 4"; plates, studs, and braces, 2" x 3"; siding and flooring, $\frac{7}{8}$" tongue and groove material, and roof $\frac{7}{8}$" material covered with patent roofing.

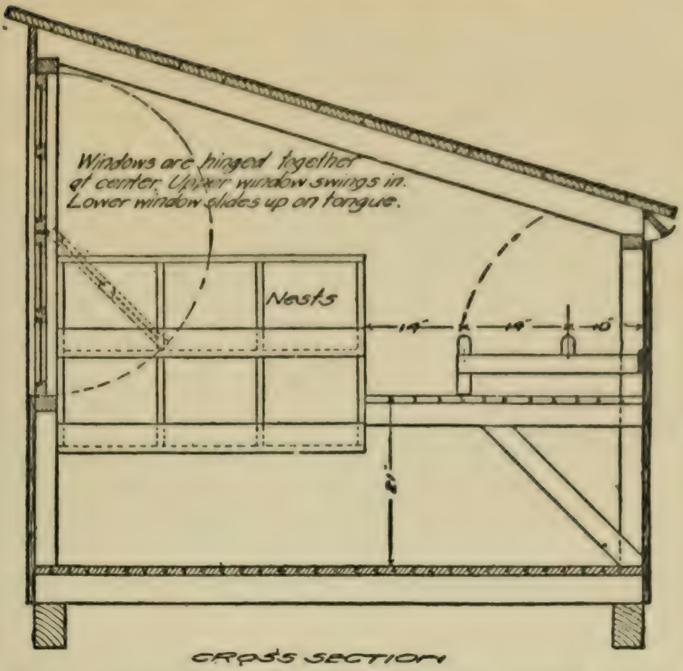

Windows are hinged together at center. Upper window swings in. Lower window slides up on tongue.
Nests
14"
14"
10"
2'
CROSS SECTION

Fig. 156.—View showing interior of colony house for 25 hens.

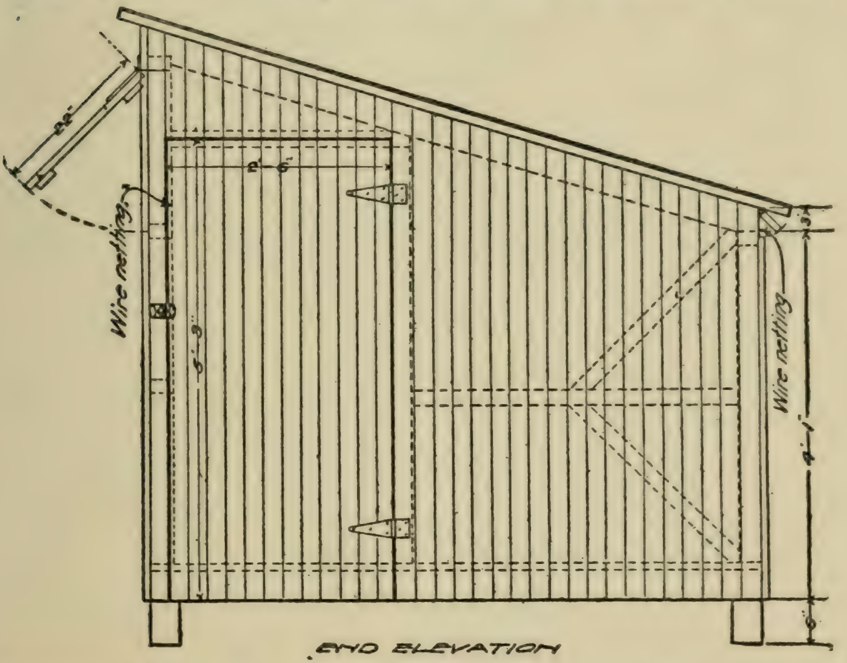


Fig. 157.—End view of colony house for 25 hens, showing arrangement of door.

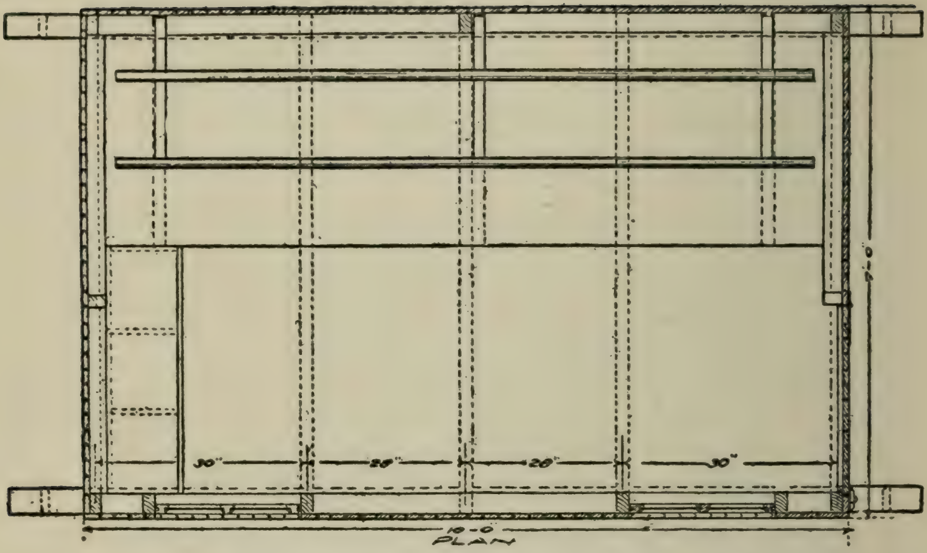


Fig. 158.—Floor plan of colony house as shown in Fig. 155.

BILL OF MATERIAL FOR COLONY GROWING COOP

(As shown in Fig. 159.)

Use.	Size. *Inches.*	Number of pieces.	Length. *Feet.*	Board measure. *Feet.*
Sills (runners)	3 by 4	2	8	16
Joists	2 by 4	2	10	14
Studs and braces	2 by 3	8	12	48
Rafters	2 by 4	3	12	24
Total				102
⅞-inch matched flooring (sides and floor)				175
⅞-inch sheathing surfaced on one side (roof)				36

Roofing paper, ½ roll.
Hinges and hardware.

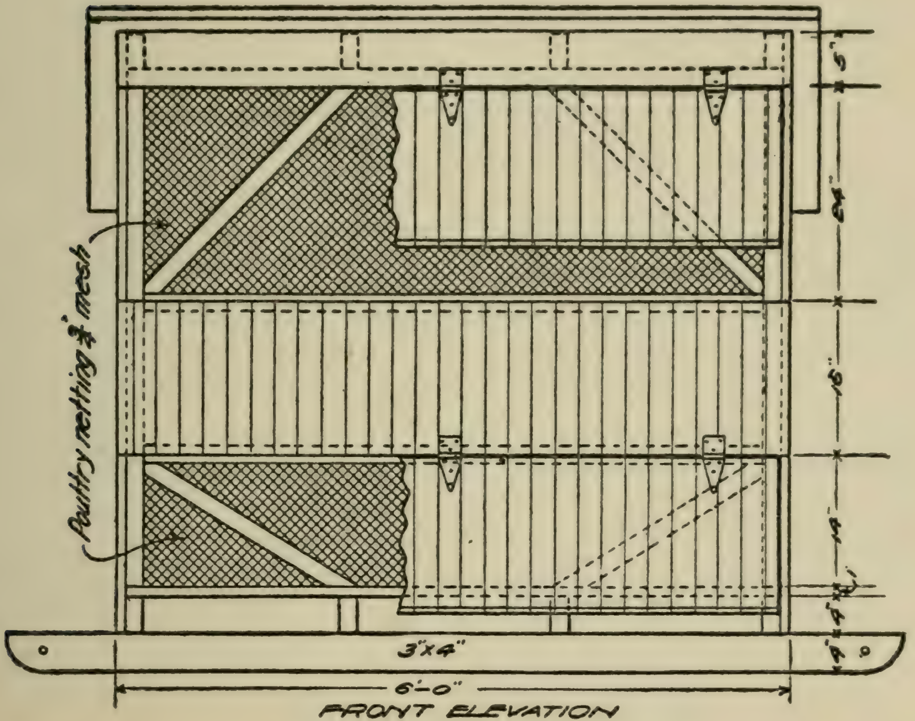


Fig. 159.—Front view of colony growing coop used at Government Poultry Farm, Beltsville, Md.

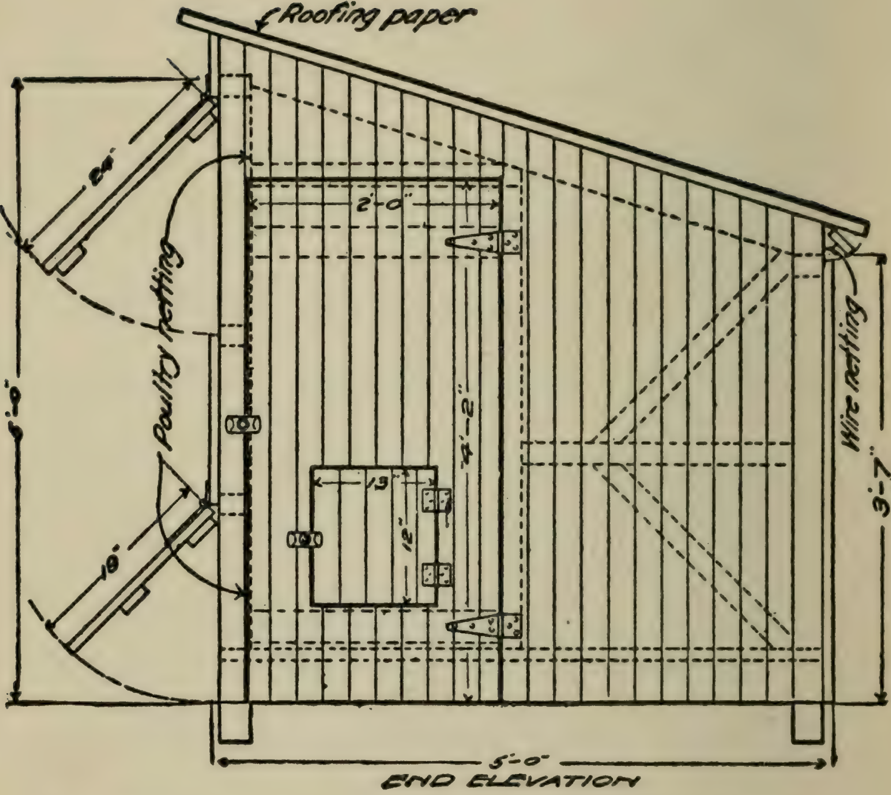


Fig. 160.—End view of colony growing coop as shown in Fig. 159.

SPECIFICATIONS FOR MODEL WISCONSIN BARN

(As shown in Fig. 162.)

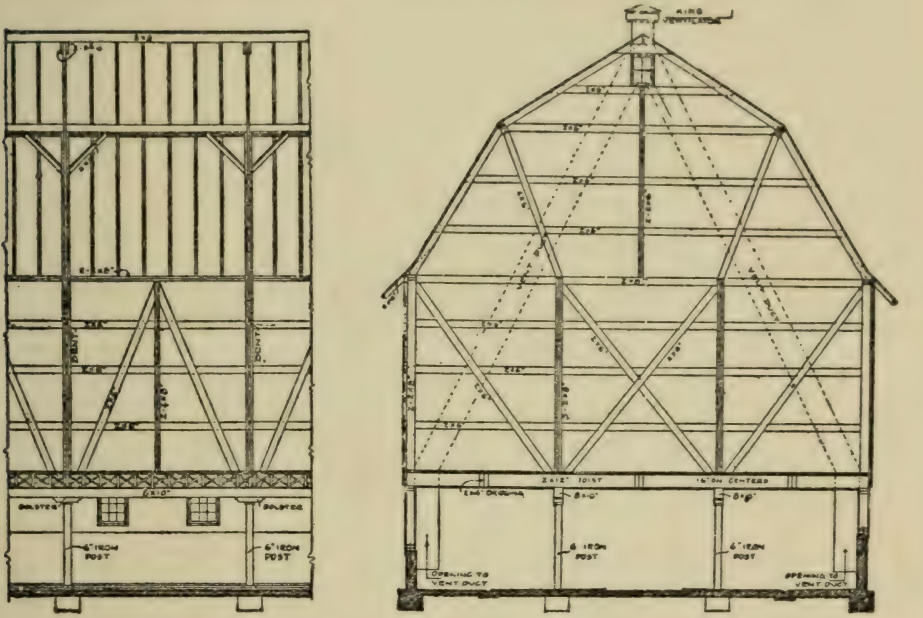
Concrete wall against bank is 4 ft. 6 in. high; on other side, 3 ft.

One-half inch bolts are put in wall every 10 feet to hold sill in place.

The floors in basement are made of concrete of proper consistency, and stall floors are given 1 inch pitch.

All framing lumber is to be as follows:

Girders,	8 in. x 10 in.
Floor joists,	2 in. x 12 in.
Studding,	2 in. x 8 in.
Rafters,	2 in. x 8 in.
Roofing,	2 in. x 6 in.
Siding,	1 in. x 8 in. center matched.



Side view. End construction.

Fig. 161.—Other details of Wisconsin Model Barn.

(As shown in floor plan, Fig. 162.)

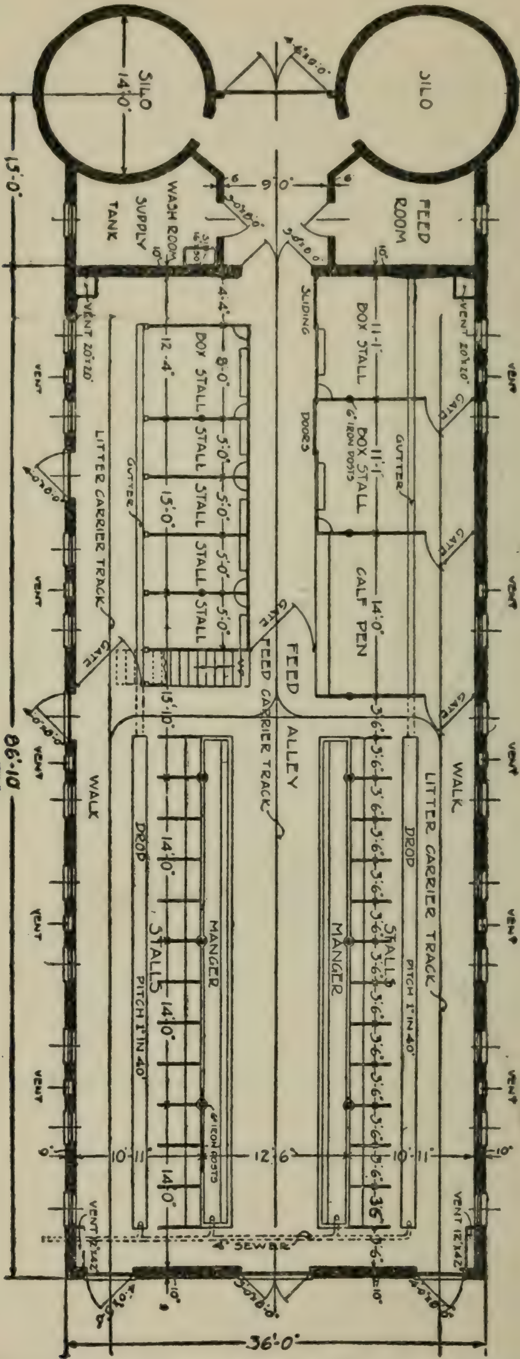


Fig. 162.—Basement floor plan of Model Barn on Wisconsin State Fair Grounds.

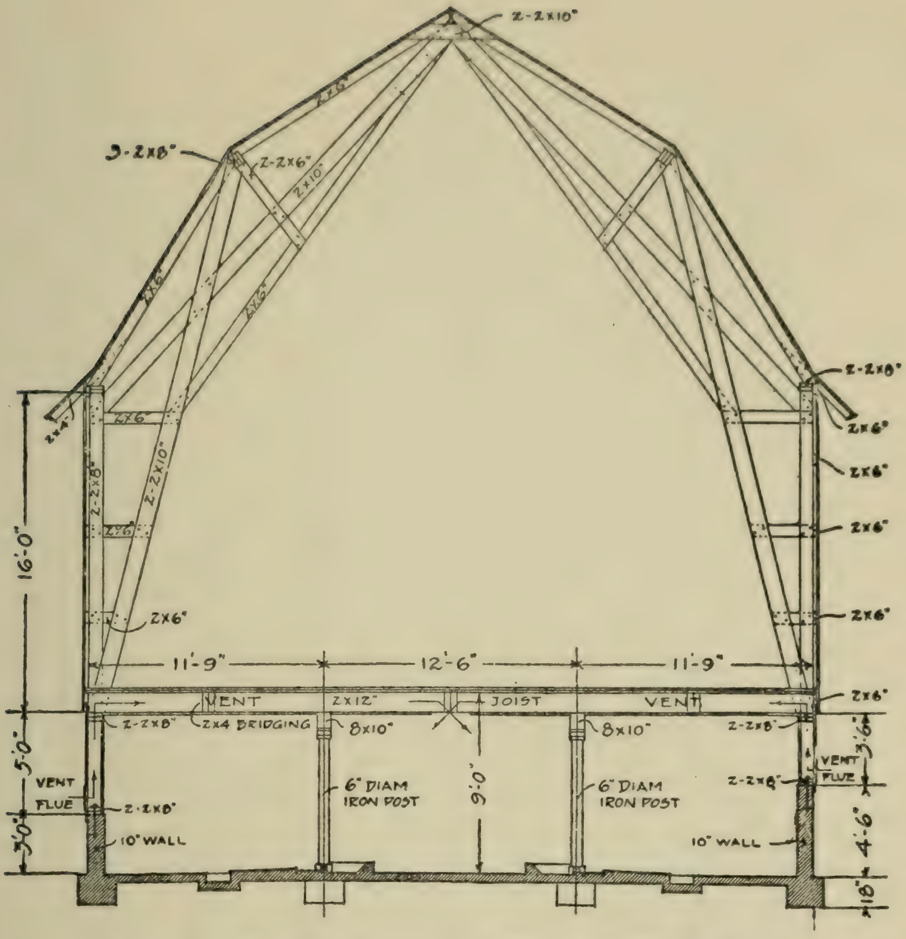


Fig. 163.—Detail of truss for Wisconsin Model Barn.
(As shown in floor plan, Fig. 162.)

BILL OF MATERIAL AND COST AT TIME OF ERECTION OF DAIRY BARN AS SHOWN IN FIG. 164

DIMENSIONS, 84 X 34 FEET. 12 FEET FROM FOUNDATION TO EAVES.

34 sills	6x8x12½
20 posts	5x5x12
12 posts	6x6x7
14 top posts	5x5x13
90 streamers and plates	2x5x12
14 girders	6x6x12
16 plates	4x6x12
8 ties	2x6x10
40 joists	2x8x10
80 joists	2x8x12
80 rafters	2x5x16
80 rafters	2x5x8
30 braces	2x5x14
Siding, 3300 ft.	1x12x12
270 strips	¾x4x12
50 pieces cornice	1x7x12
Sheathing, 4000 ft.	

Total, 17,191 feet.

DETAILED COST.

17,000 feet of lumber at $2 per hundred	$ 340.00
Yellow pine t. & g. flooring for loft floor (second grade)	72.00
Shingles	170.00
Windows	25.00
Hinges, bolts, and nails	46.00
Carpentry work	200.00
Labor laying foundation, one man 3 days at $2.50 per day	7.50
60 barrels Portland cement for concrete floor	105.00
Labor for laying concrete floor	33.00
48 iron swinging stanchions set in wooden framework	72.00
Total	**$1070.50**

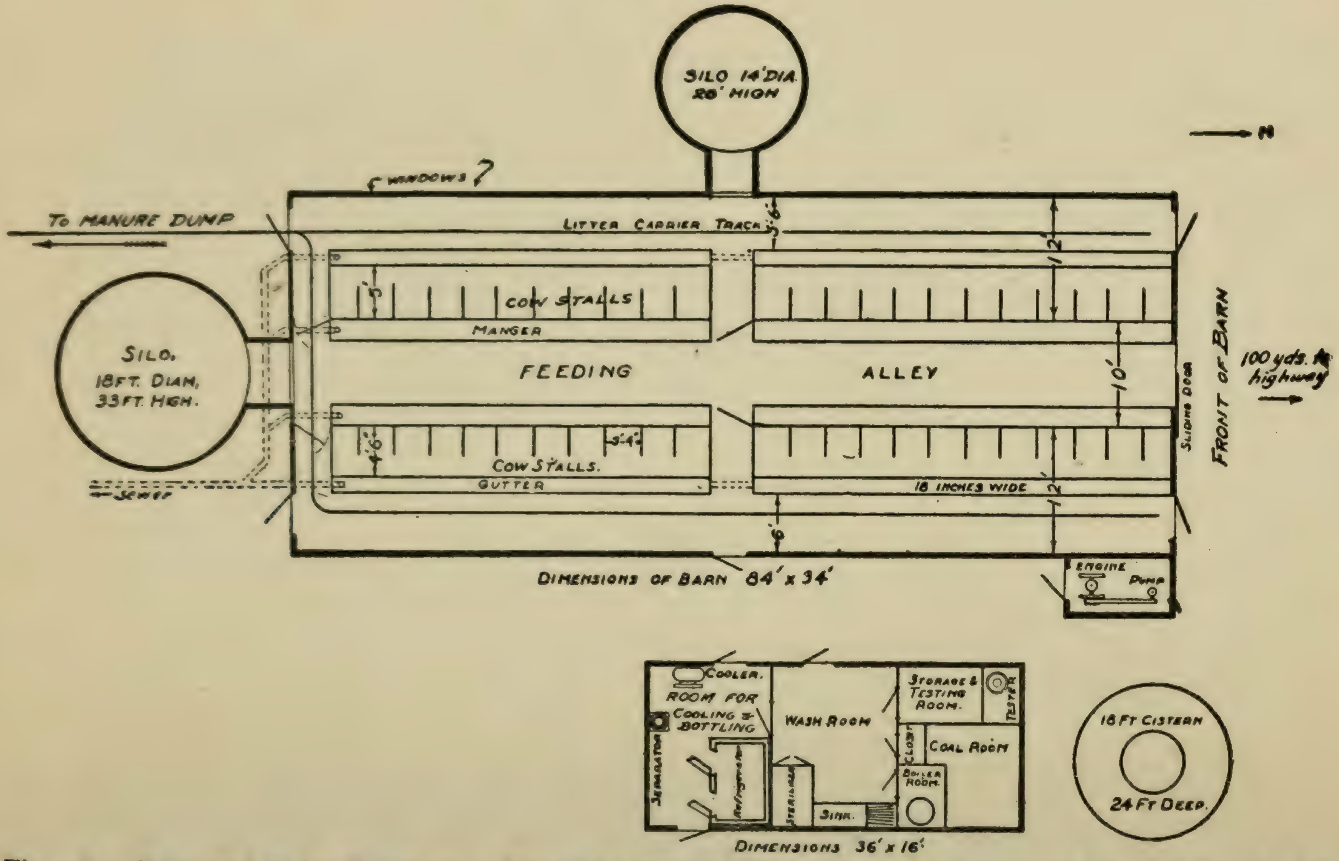


Fig. 164.—Barn and Dairy House on a Kentucky Certified Dairy Farm. Separate stable is provided for young stock, cows with calves, and so on.

DETAILED COST AND BILL OF MATERIALS FOR FOUR-ROW MILKING STABLE AS SHOWN IN FIG. 165

This estimate is for the barn complete, ready for occupancy. The owner graded the ground to a level and furnished stanchions, manure carrier, and track for same. The contractor furnished all other material and labor, put in all concrete work, framework for iron stanchions, and stall partitions.

Digging for trenches and pillars	$ 5.00	
207 feet of ground wall, size 8x18 equal 208 cu. ft.		
32 pillars, size 12x12x24 equal 75 cu. ft.		
240 ft. side wall above ground, size 6x12 equal 120 cu. ft.		
16 perch of concrete at $6.50 equal 403 cu. ft.	104.00	
3922 sq. ft. cement work at 16 cents	627.52	
50 anchor bolts, size ½x20 inches at 8 cents	4.00	
Top rail for stanchion 1½ black pipe equal 210 lin. ft.		
42 upright bars 1½x5 black pipe equal 210 lin. ft.		
66 bent bars 1½x5 black pipe equal 330 lin. ft.		
1½ inch black pipe at 7½ cents equal 750 lin. ft.	56.25	
62 fittings for stanchions at 25 cents	15.50	
Bending 66 stall pieces at 10 cents	6.60	
80 black 1½ T's at 17 cents	13.60	
170 threads 1½ pipe at 4 cents	6.80	
		$839.27

Framing bill for sheds—		
250 lin. ft. sill 2x4	166 ft.	
130 lin. ft. plate 2x4	86 ft.	
66 pieces rafters 2x4x12	528 ft.	
66 pieces side studs (cut) 2x4x12	264 ft.	
24 pieces end studs (cut) 2x4x14	224 ft.	
Lumber at $22.50	1268 ft.	$ 28.53

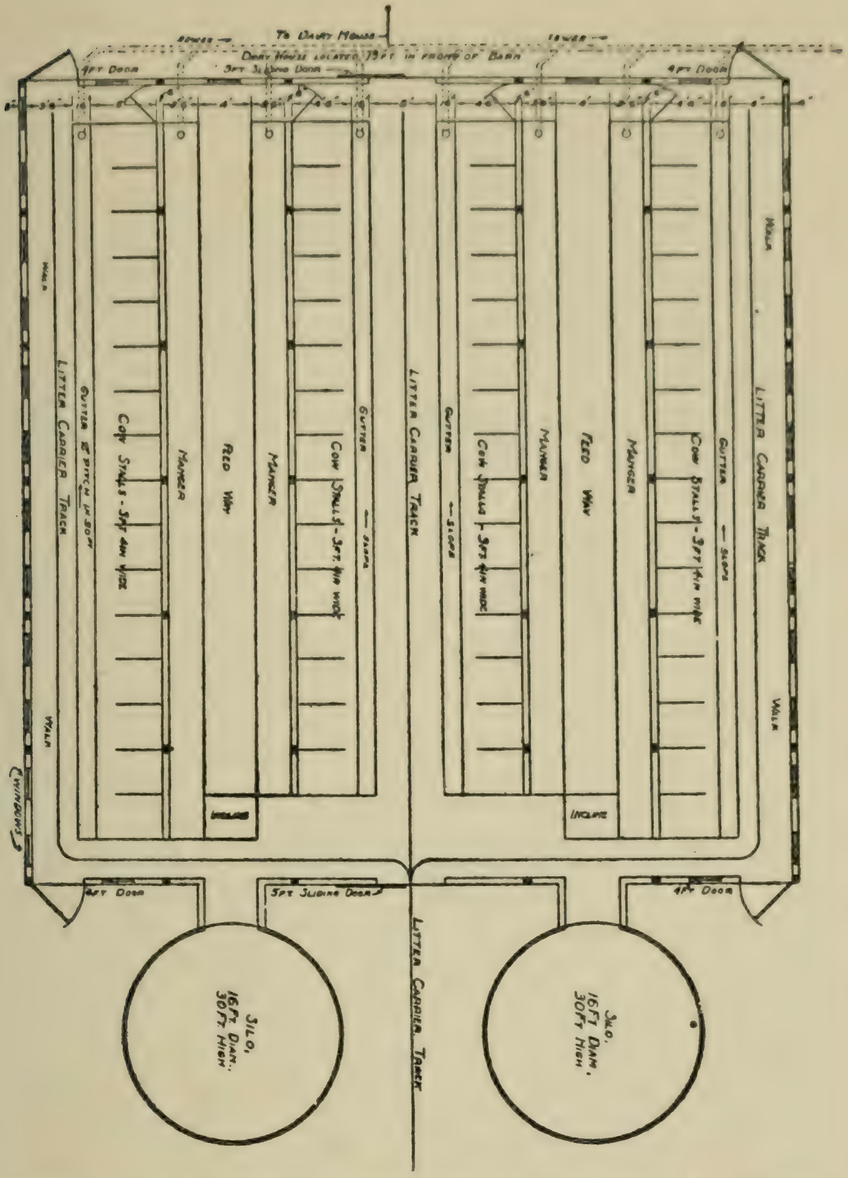


Fig. 165.—Four-row milking stable on a Kentucky Dairy Farm.

For main barn—

16 pieces side posts 6x8x20	1280 ft.		
16 pieces inner posts 6x8x10	640 ft.		
128 lin. ft. 6x10 inside girder (use 2x10's)	640 ft.		
130 lin. ft. 4x10 outside girder (use 2x10's)	433 ft.		
2 pieces 6x6x16 cap	96 ft.		
4 door posts 4x4x14	76 ft.		
4 door posts 4x4x12	64 ft.		
130 lin. ft. 4x6 top plates (use 2x6's)	260 ft.		
66 pieces upper side studs (2x6x12)	792 ft.		
130 lin. ft. 2x10 side stringer	216 ft.		
32 center joists 2x12x18	1152 ft.		
164 side joists 2x10x9	2460 ft.		
35 studs for end below eaves 2x4x12	280 ft.		
35 studs for end above eaves 2x6x20	700 ft.		
54 pieces for window frames 2x6x12	640 ft.		
8 storm braces 2x8x12	240 ft.		
Uncounted	200 ft.		
Lumber at $22.50	10,169 ft.		$228.80
No. 3 flooring at $16.00, 494 feet face count		$ 76.90	
No. 3 flooring at $16.00 for roof sheathing, 3000 ft.		48.00	
No. 2 barn siding at $25.00, 6000 ft.		150.00	
32,000 cedar shingles		144.00	
16 squares composition roofing for sheds, at $2.50		40.00	
Total roofing, siding, and flooring			$458.90
Roof truss, top section, 62 pieces, 2x6x12	744 ft.		
Roof truss, side section, 62 pieces, 2x8x16	1324 ft.		
Collar beam, 31 pieces, 2x6x8	248 ft.		
Braces between top and side section, 124 pieces, 1x8x12	992 ft.		
Brace between side sections and studs, 62 pieces, 1x8x14	574 ft.		
Brace between studs and joists, 62 pieces, 1x6x8	248 ft.		
Ridge pole, 4 pieces, 1x6x16	32 ft.		
Extension at eaves, 62 pieces, 2x6x4	248 ft.		
Cornice, 15 pieces, 1x6x16	120 ft.		
Extra uncounted	200 ft.		
Lumber at $22.50	4730 ft.		$106.42

Hardware—		
2 sets of hardware complete for sliding doors	$ 6.00	
4 pairs barn door hinges at 25 cents	1.00	
Hardware for loft doors	10.00	
30 window sash, 9 lights 10x12 at $1.20	36.00	
24 window sash, 6 lights 8x10 at $0.75	18.00	
54 window strips, hinges and buttons, at $0.25	13.50	
Nails	25.00	
		$109.50
Carpentry work		$350.00
Total actual cost of this barn		$2121.42

BILL OF MATERIALS FOR TWO-WING DAIRY BARN, AS SHOWN IN FIG. 166

FOR MAIN PART OF BARN, 112 X 34 FEET.

Sills—
- West side, 8 pieces, 2x6x14.
- East side, 8 pieces, 2x6x14.
- For ends, 4 pieces, 2x6x10.

Studs—
- West side, 57 pieces, 2x6x18.
- East side, 57 pieces, 2x6x18.
- Two ends, 30 pieces, 2x6x18.
- For north end above eaves, 10 pieces, 2x6x14.
- For north end above eaves, 4 pieces, 2x6x12.
- For south end above eaves, 10 pieces, 2x6x14.
- For south end above eaves, 4 pieces, 2x6x12.
- Corner storm braces for sides, 4 pieces, 2x8x22.
- Corner storm braces for ends, 4 pieces, 2x8x22.

Plates—
- For sides (built up with 2x6's), 18 pieces, 4x6x14.
- For ends (built up with 2x6's), 2 pieces, 2x6x34.

Posts for center, 18 pieces, 6x6x7.
Girders, 16 pieces, 6x10x14.
Side joists, 114 pieces, 2x10x12.
Center joists, 57 pieces, 2x10x10.
Joist bearer or ribbon, 16 pieces, 1x6x14.

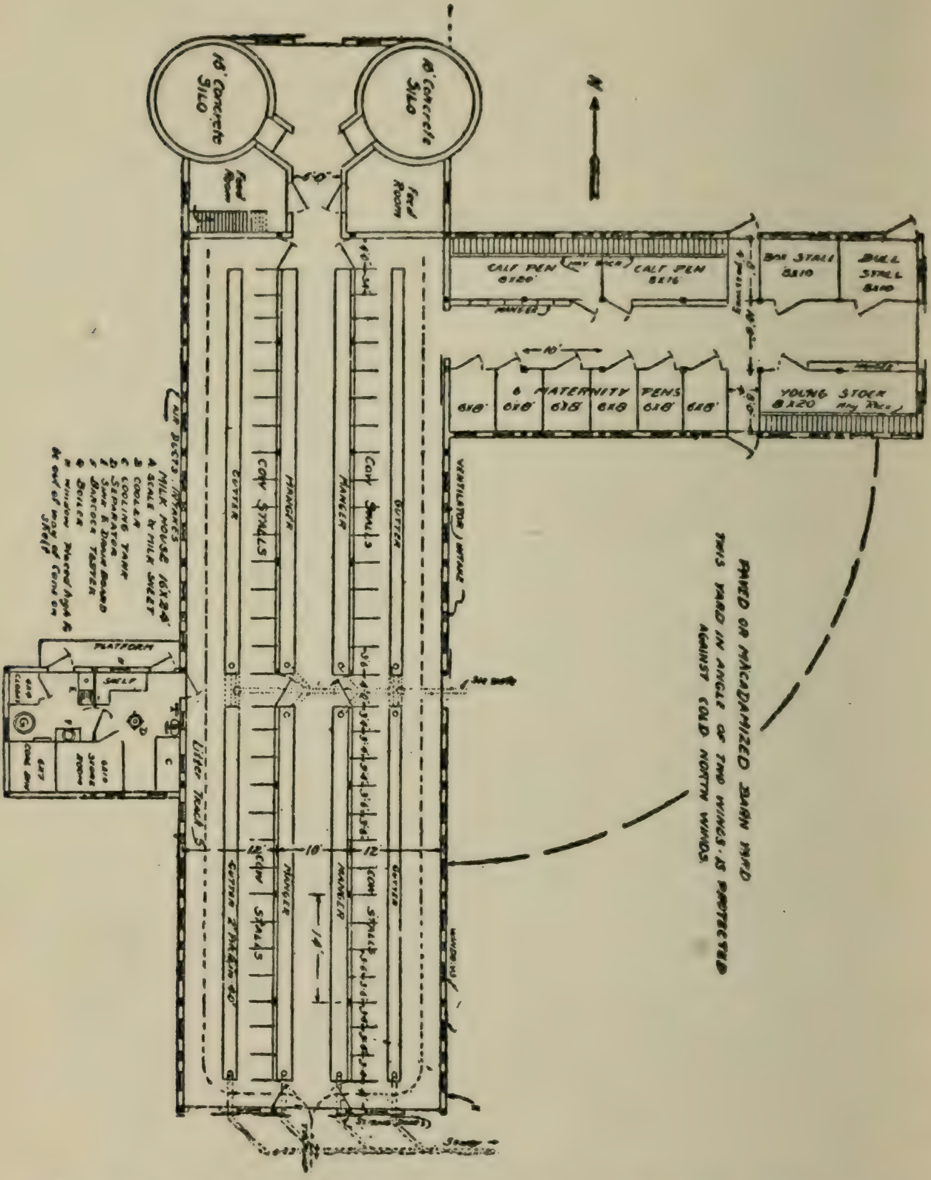


Fig. 166.—Two-wing dairy barn for 58 cows and extra stock. Dimensions of main barn 112'x34'—14' bents. Dimensions of wing 60'x26'—10' bents.

Roof Truss—

- Top section of rafters, 114 pieces, 2x6x12.
- Ridge pole, 9 pieces, 1x6x16.
- Side section of rafters, 114 pieces, 2x6x14.
- Braces between side and top sections, 228 pieces, 1x6x12.
- Braces between side sections and stud, 114 pieces, 1x6x14.
- Braces between studs and joists, 114 pieces, 1x6x8.
- Braces at top (collar beam), 57 pieces, 2x6x6.
- Extension at eaves, 114 pieces, 2x6x4.
- Cornice, 20 pieces, 1x6x16.

Window framing, 29 pieces, ⅞x8x14.
Weather-strips for windows, 29 pieces, ½x1x12.
Loft floor, t. and g., yellow pine, second grade, floor space 4000 sq. ft.
Roofing, 6500 sq. ft. actual surface, 58,500 shingles.
4 in. sheathing, 4 in. spacing, 4000 sq. ft.
Siding (drop siding), No. 2 grade—

- For sides 4000 sq. ft.
- For ends 2000 sq. ft.

Hardware—

- 6 kegs of 20d. nails, 600 lbs.
- 8 kegs 8d. nails, 400 lbs.
- Roofing nails, 3 lbs. per 1000 shingles, 180 lbs.
- 9 pairs door hinges.
- 29 pairs 3 in. strap hinges for windows.
- 29 window sash (9 10x12 lights).
- 60 feet track for sliding barn doors.
- 6 pairs hangers complete.

WING FOR MAIN BARN. SIZE OF WING 26 X 60 FT., GABLE ROOF. 16 FEET TO EAVES.

Sills—

- North side, 5 pieces, 2x6x12.
- South side, 5 pieces, 2x6x12.
- End, 2 pieces, 2x6x10.

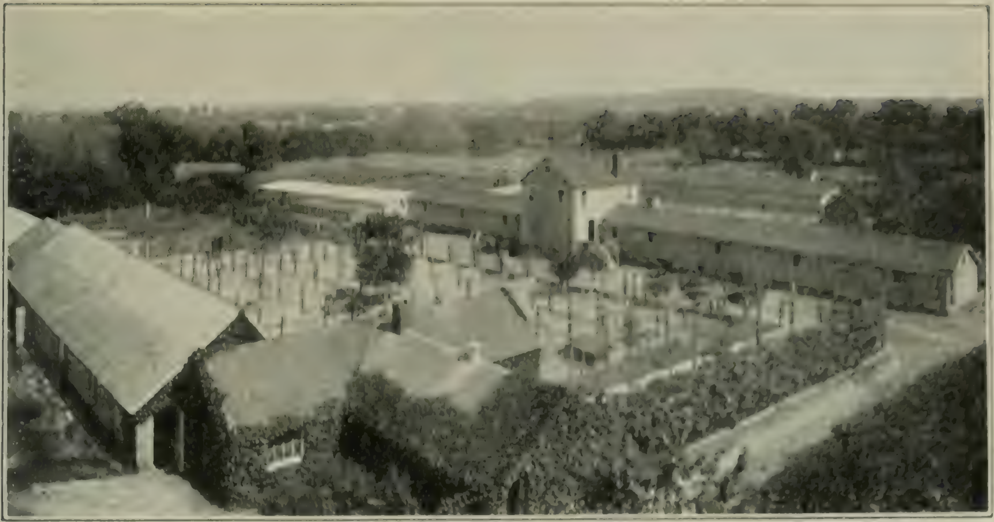
Studs—

- For north side, 30 pieces, 2x6x16.
- For south side, 30 pieces, 2x6x16.
- For end, 10 pieces, 2x6x16.
- For end above plate, 8 pieces, 2x6x12.
- For end above plate, 3 pieces, 2x6x8.

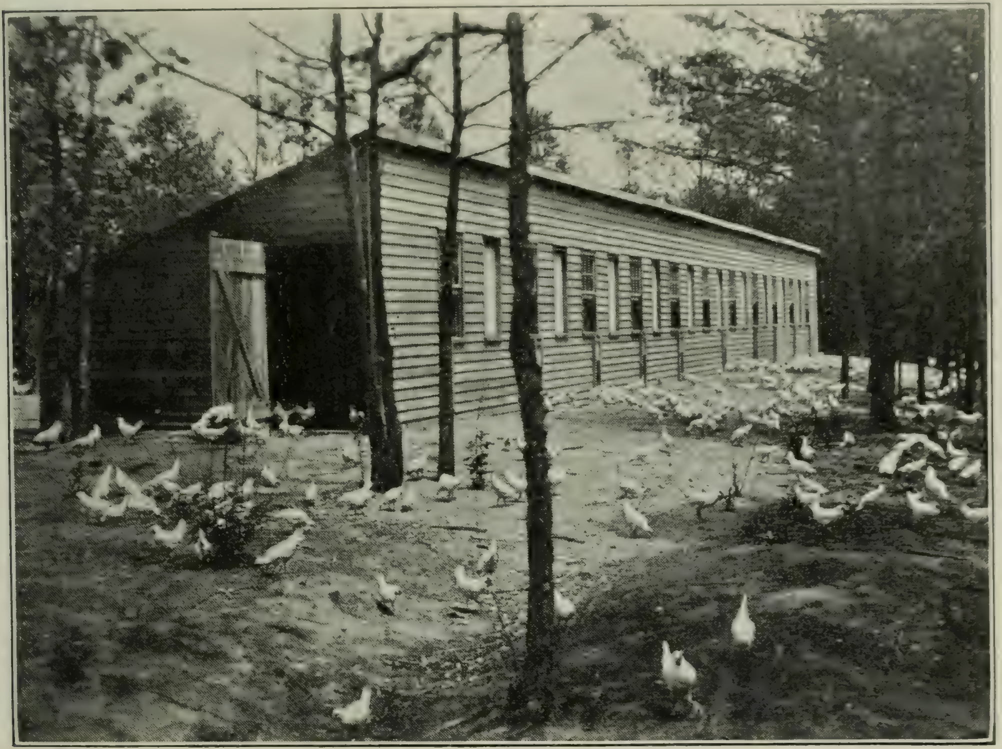
Plates—
North side (nail 2x6's together), 1 piece, 4x6x60.
South side (nail 2x6's together), 1 piece, 4x6x60.
End, 1 piece, 4x6x26.
Center posts, 14 pieces, 6x6x7.
Girders, 12 pieces, 6x10x10.
Girder support or ribbon, 12 pieces 2x6x10.
Side joists, 62 pieces, 2x10x8.
Center joists, 31 pieces, 2x10x10.
Window framing, 23 pieces, ⅞x8x14.
Window weather-strips, 23 pieces, ½x1x12.
Rafters (gable roof), 62 pieces, 2x8x18.
Ridge pole, 4 pieces, 1x8x16.
Collar beam, 31 pieces, 2x8x8.
Extension at eaves, 13 pieces 2x4x10 (cut up into 2 ft. 6 in. lengths).
Loft floor, tongued and grooved yellow pine No. 2 grade—
1700 square feet required.
Roofing shingles required 20,000.
Sheathing for roof required 1500 square feet.
4 in. sheathing, 4 inch spacing.
Drop siding No. 2 grade—
For sides 2000 square feet.
For ends 600 square feet.
For stalls and pen partitions, mangers, etc., 2000 sq. feet of 1 in. stuff.
Hardware—
Shingle nails, 60 pounds.
2 kegs 20d. nails, 200 pounds.
4 kegs 8d. nails, 400 pounds.
14 pairs door hinges.
23 pairs window hinges.
20 feet barn door track.
2 pairs barn door hangers.
23 window sash, 9 10x12 lights.

ENTRY AND FEED ROOMS BETWEEN SILOS AND MAIN BARN. EIGHT FT. TO EAVES. SELF-SUPPORTING ROOF.

Sills—
Side, 2 pieces, 2x4x10.
End, 2 pieces, 2x4x14.
Center, 2 pieces, 2x4x14.
Plates—
Side, 2 pieces, 2x4x10.
End, 2 pieces, 2x4x12.



Centralized poultry plant of substantial buildings



Continuous type of laying house of simple construction

Studs—
- For sides, 10 pieces, 2x4x8.
- For ends below eaves, 12 pieces, 2x4x8.
- For ends above eaves, 6 pieces, 2x4x14.
- For ends above eaves, 4 pieces, 2x4x18.
- Posts, 4 pieces, 4x4x7.
- Girders, 4 pieces, 4x10x12.
- Side joists, 10 pieces, 2x6x12.
- Center joists, 5 pieces, 2x6x10.
- Center joists, 6 pieces, 2x6x14.
- Center joists, 2 pieces, 2x6x16.

No. 2 tongued and grooved flooring for loft floor, 500 square feet.

No. 2 tongued and grooved flooring for inside walls, 250 square feet.

Boxing (No. 2 grade)—
- For sides, 200 square feet.
- For end, 500 square feet.
- 7200 shingles for roof.
- 500 square feet, 4 inch sheathing, 4 inch spacing.
- Window framing, 6 pieces, ⅞x8x14.
- Window weather-strips, 6 pieces, ½x1x12.

Roof truss—
- Top section of rafters, 18 pieces, 2x6x12.
- Side section of rafters, 10 pieces, 2x6x14.
- Ridge pole, 2 pieces, 1x6x12.
- Braces between side and top, 36 pieces, 1x6x12.
- Braces at top (collar beam), 24 pieces, 2x6x6.
- Extension at eaves, 10 pieces, 2x6x4.
- Cornice, 4 pieces, 1x6x16.

Hardware—
- Roofing nails required 25 pounds.
- 20d. nails, 50 pounds.
- 8d. nails, 75 pounds.
- 6 window sash (9 10x12 lights).
- 6 pairs window hinges.
- 2 pairs door hinges.
- 12 ft. barn door track.
- 1 pair barn door hangers complete.

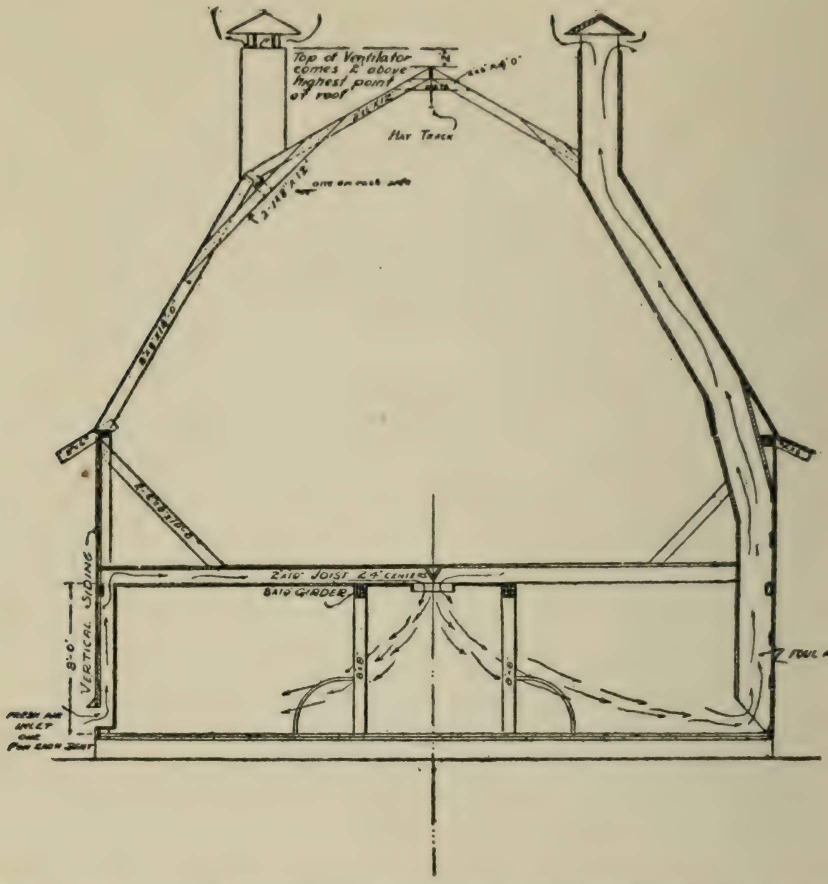

Top of Ventilator comes 2' above highest point of roof
Hay Track
2-1x8"x12' one on each side
Vertical Siding
8'-0"
2x10" Joist 24" centers
8x10" Girder
8'-8"
Fresh air inlet one for each bent
Foul air duct

Fig. 167.—Typical ventilating system in a Kentucky Dairy Farm Barn.

A series of fresh-air ducts are placed on each side of the barn near the floor. The fresh-air ducts pass between studs and joists and deliver over the heads of the cows. One duct for each bent is usually sufficient. The foul-air ducts will depend for a location upon the situations available. They should not obstruct the passageways. To avoid this they may be placed in the four corners of the building.

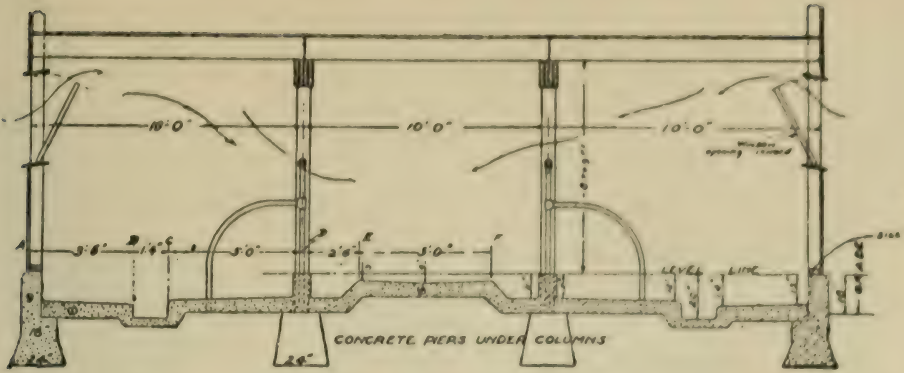


Fig. 168.—Section through 30-foot dairy barn, showing arrangement of stanchions for cows facing inward.

The following dimensions are for barns of other widths:

FOR BARN 32 FT. WIDE

Side bents	11 ft.
Central bent	10 ft.
Walk behind cows (A–B)	4 ft. 8 ins.
Stall platform (C–D)	5 ft.
Manger (D–E)	2 ft. 6 ins.
Feed-way (E–F)	5 ft.

FOR BARN 34 FT. WIDE

Side bents	12 ft.
Central bent	10 ft.
Walk behind cows (A–B)	5 ft. 8 ins.
Stall platform. (C–D)	5 ft.
Manger (D–E)	2 ft. 6 ins.
Feed-way (E–F)	5 ft.

FOR BARN 36 FT. WIDE

Side bents	12 ft.
Central bent	12 ft.
Walk behind cows (A–B)	5 ft. 8 ins.
Stall platform (C–D)	5 ft.
Manger (D–E)	3 ft.
Feed-way (E–F)	6 ft.

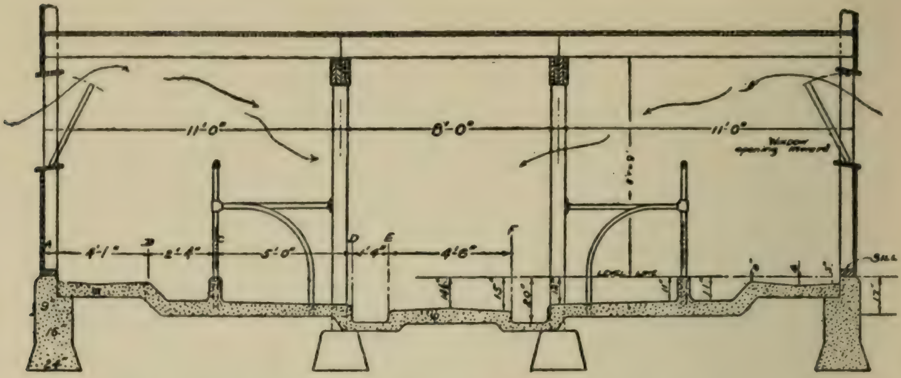


Fig. 169.—Section through 30-foot dairy barn, showing arrangement of stanchions for cows facing outward.

The following dimensions are for barns of other widths:

FOR BARN 32 FT. WIDE

Side bents	12 ft.
Central bent	8 ft.
Feed-ways in front of cows (A–B)	5 ft. 1 in.
Mangers (B–C)	2 ft. 4 ins.
Stall platform (C–D)	5 ft.
Drive-way (E–F)	4 ft. 6 ins.

FOR BARN 34 FT. WIDE

Side bents	12 ft.
Central bent	10 ft.
Feed-ways in front of cows (A–B)	5 ft. 1 in.
Manger (B–C)	2 ft. 4 ins.
Stall platform (C–D)	5 ft.
Drive-way (E–F)	6 ft. 6 ins.

FOR BARN 36 FT. WIDE

Side bents	12 ft.
Central bent	12 ft.
Feed-ways in front of cows (A–B)	5 ft. 1 in.
Manger (B–C)	2 ft. 4 ins.
Stall platform (C–D)	5 ft.
Drive-way (E–F)	8 ft.6 ins.

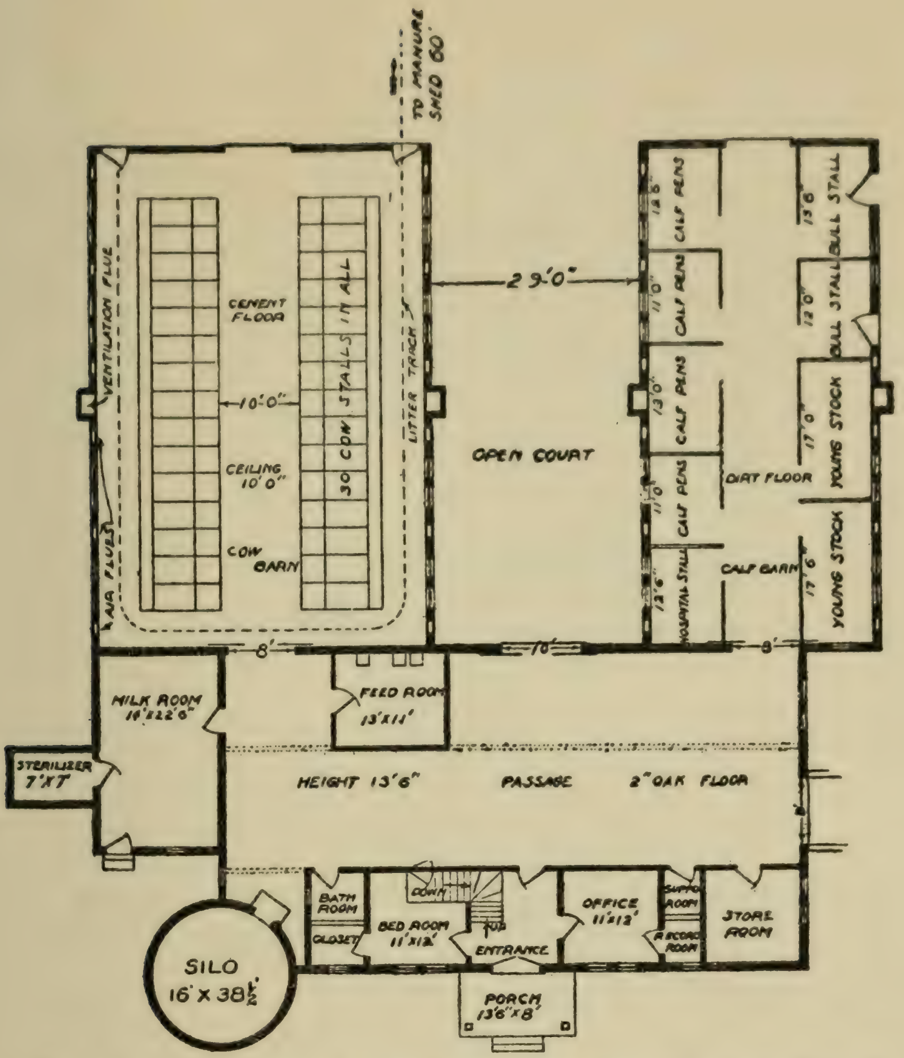


Fig. 170.—Ground plan of dairy barn on the Kentucky Agricultural Experiment Station. The building consists of a main portion of two stories and a basement 68 feet long by 37 feet wide, two ells each 60 feet long, and a milk room 14 by 22 feet.

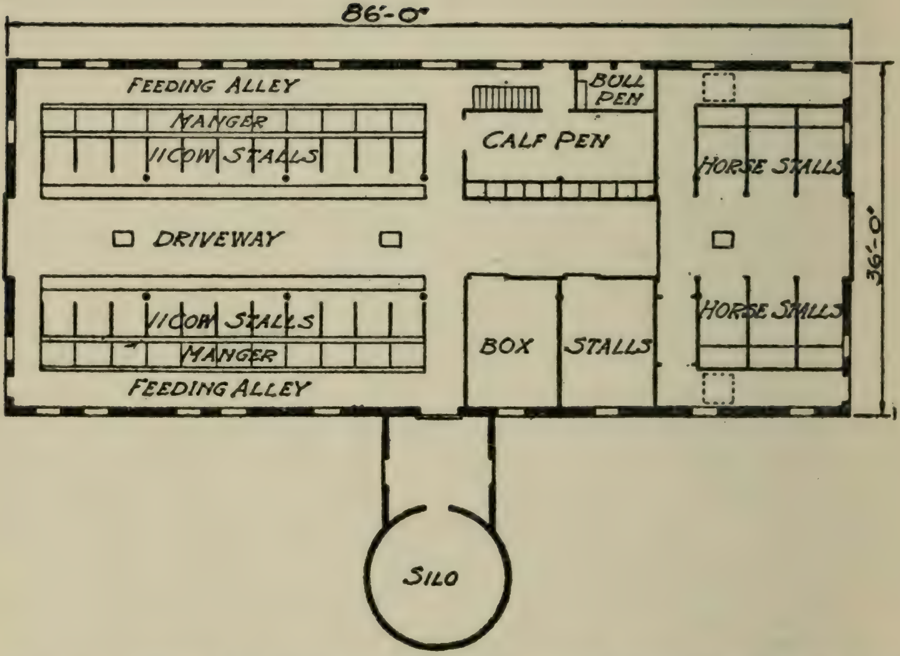


Fig. 171.—Plan of a general purpose barn. The building is 36 feet wide and 86 feet long, with the cows facing outward.

APPENDIX

MENSURATION

LENGTH

Circumference of circle = diameter × 3.1416.

Diameter of circle = circumference × 0.3183.

Side of square of equal periphery as circle = diameter × 0.7854.

Diameter of circle of equal periphery as square = side × 1.2732.

Side of an inscribed square = diameter of circle × 0.7071.

Length of arc = No. of degrees × diameter × 0.008727.

Circumference of circle whose diameter is 1 = 3.14159265.

AREA

Triangle = base × half perpendicular height.

Parallelogram = base × perpendicular height.

Trapezoid = half the sum of the parallel sides × perpendicular height.

Trapezium, found by dividing into two triangles.

Circle = diameter squared × 0.7854; or,
= circumference squared × 0.07958.

Sector of circle = length of arc × half radius.

Segment of circle = area of sector less triangle.

Side of square of equal area as circle = diameter × 0.8862; also, = circumference × 0.2821.

Diameter of circle of equal area as square = side × 1.1284.

Parabola = base × $\frac{2}{3}$ height.

Ellipse = long diameter × short diameter × 0.7854.

Regular polygon = sum of sides × half perpendicular distance from center to sides.

Surface of cylinder = circumference × height + area of both ends.

Surface of sphere = diameter squared × 3.1416; or,
= circumference × diameter.

Surface of a right pyramid or cone = periphery or circumference of base × half slant height.

Surface of a frustrum of a regular right pyramid or cone = sum of peripheries or circumferences of the two ends × half slant height + area of both ends.

SOLID CONTENTS

Prism, right or oblique, = area of base × perpendicular height.

Cylinder, right or oblique, = area of section at right angles to sides × length of side.

Sphere = diameter cubed × 0.5236; or,
= surface × $\frac{1}{6}$ diameter.

Pyramid or cone, right or oblique, regular or irregular = area of base × $\frac{1}{3}$ perpendicular height.

Avoirdupois or Ordinary Commercial Weight

UNITED STATES AND BRITISH

Ton.	Cwts.	Pounds.	Ounces.
1.	20.	2240.	35,840
0.050	1.	112.	1,792
	0.0089	1.	16
		0.0625	1

1 pound = 27.7 cubic inches of distilled water at its maximum density (39° Fahrenheit).

Long Measure

UNITED STATES AND BRITISH

Mile.	Rods.	Yards.	Feet.	Inches.
1.	320.	1760.	5280.	63,360
0.003125	1.	5.5	16.5	198
0.000568	0.1818	1.	3.	36
0.0001894	0.0606	0.3333	1.	12
0.0000158	0.005051	0.02778	0.08333	1

The British measures are shorter than those of the U. S. by about 1 part in 17,230 or 3.677 inches in a mile.

A fathom = 6 feet. A Gunter's surveying chain = 66 feet or 4 rods, 80 chains making a mile.

Square or Land Measure

UNITED STATES AND BRITISH

Sq. mile.	Acres.	Sq. rods.	Sq. yards.	Sq. feet.	Sq. inches.
1	640	102,400.	3,097,600.	27,878,400.	
	1	160.	4,840.	43,560.	6,272,640
		1.	30.25	272.25	39,204
		0.0331	1.	9.	1,296
			0.111	1.	144
				0.00694	1

CUBIC OR SOLID MEASURE

UNITED STATES AND BRITISH

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.

A cord of wood = 4′ × 4′ × 8′ = 128 cubic feet.

A perch of masonry = 16.5′ × 1.5′ × 1′ = 24.75 cubic feet, but is generally assumed at 25 cubic feet.

DRY MEASURE

UNITED STATES ONLY

Struck bushel.	Pecks.	Quarts.	Pints.	Gallons.	Cubic inches.
1	4	32.	64	8.	2150.
	1	8.	16	2.	537.6
		1.	2	0.25	67.2
		0.5	1	0.125	33.6
		4.	8	1.	268.8

A gallon of liquid measure = 231 cubic inches.

A heaped bushel = 1¼ struck bushels. The cone in a heaped bushel must not be less than 6 inches high.

To reduce U. S. dry measures to British imperial of the same name, divide by 1.032.

NAUTICAL MEASURE

A nautical or sea mile is the length of a minute of longitude of the earth at the equator at the level of the sea. It is assumed as 6086.07 feet = 1.152664 statute or land miles by the United States Coast Survey.

3 nautical miles = 1 league.

WEIGHT OF A CUBIC FOOT OF SUBSTANCES

NAMES OF SUBSTANCES	Average weight, pounds.
Aluminum	162
Anthracite, solid, of Pennsylvania	93
Anthracite, broken, loose	54
Anthracite, broken, moderately shaken	58
Ash, American white, dry	38
Asphaltum	87
Brass (Copper and Zinc), cast	504
Brass, rolled	524
Brick, best pressed	150
Brick, common hard	125
Brick, soft, inferior	100
Brickwork, pressed brick	140
Brickwork, ordinary	112
Cement, loose, Portland	90
Cherry, dry	42
Chestnut, dry	41
Clay, potters', dry	119
Clay in lump, loose	63
Coal, bituminous, solid	84
Coal, bituminous, broken, loose	49
Coke, loose, of good coal	26.3
Copper, cast	542
Copper, rolled	548
Earth, common loam, dry, loose	76
Earth, common loam, dry, moderately rammed	95
Earth as a soft flowing mud	108
Ebony, dry	76
Elm, dry	35
Flint	162
Glass, common window	157
Gneiss, common	168

	Average weight, pounds.
Gold, cast, pure, or 24 carat	1204
Gold, pure, hammered	1217
Granite	170
Gravel, about the same as sand, which see.	
Gypsum (plaster of Paris)	142
Hemlock, dry	25
Hickory, dry	53
Ice	58.7
Iron, cast	450
Iron, wrought, purest	485
Iron, wrought, average	480
Ivory	114
Lead	711
Lignum vitæ, dry	83
Lime, quick, ground, loose, or in small lumps	53
Lime, quick, ground, loose, thoroughly shaken	75
Limestones and Marbles	168
Limestones and Marbles, loose, in irregular fragments	96
Magnesium	109
Mahogany, Spanish, dry	53
Mahogany, Honduras, dry	35
Maple, dry	49
Marbles, see Limestones.	
Masonry, of granite or limestone, well dressed	165
Masonry, of mortar rubble	154
Masonry, of dry rubble	138
Masonry, of sandstone, well dressed,	144
Mercury, at 32° Fahrenheit	849
Mica	183
Mortar, hardened	103
Mud, dry, close	80 to 110
Mud, wet, fluid, maximum	120
Oak, live, dry	59
Oak, white, dry	50

	Average weight, pounds.
Oak, other kinds	32 to 45
Petroleum	55
Pine, white, dry	25
Pine, yellow, Northern	34
Pine, yellow, Southern	45
Platinum	1342
Quartz, common, pure	165
Rosin	69
Salt, coarse	45
Salt, fine, for table use	49
Sand, of pure quartz, dry, loose	90 to 106
Sand, well shaken	99 to 117
Sand, perfectly wet	120 to 140
Sandstones fit for building	151
Shales, red or black	162
Silver	655
Slate	175
Snow, freshly fallen	5 to 12
Snow, moistened and compacted by rain	15 to 50
Spruce, dry	25
Steel	490
Sulphur	125
Sycamore, dry	37
Tar	62
Tin, cast	459
Turf or Peat, dry, unpressed	20 to 30
Walnut, black dry,	38
Water, pure rain or distilled, at 60° Fahrenheit	62⅓
Water, sea	64
Wax, bees	60.5
Zinc or Spelter	437.5

Green timbers usually weigh from one-fifth to one-half more than dry.

SIZES AND WEIGHTS OF ROOFING MATERIALS.

Slate.

Number and superficial area of slate required for one square of roof.
(1 square = 100 square feet.)

Dimensions in Inches.	Number per Square.	Superficial Area in Sq. Ft.	Dimensions in Inches.	Number per Square.	Superficial Area in Sq. Ft.
6 × 12	533	267	12 × 18	160	240
7 × 12	457	....	10 × 20	169	235
8 × 12	400	....	11 × 20	154	
9 × 12	355	....	12 × 20	141	
7 × 14	374	254	14 × 20	121	
8 × 14	327	....	16 × 20	137	
9 × 14	291	....	12 × 22	126	231
10 × 14	261	....	14 × 22	108	
8 × 16	277	246	12 × 24	114	228
9 × 16	246	....	14 × 24	98	
10 × 16	221	....	16 × 24	86	
9 × 18	213	240	14 × 26	89	225
10 × 18	192	....	16 × 26	78	

As slate is usually laid, the number of square feet of roof covered by one slate can be obtained from the following formula:

$$\frac{\text{width} \times (\text{length} - 3 \text{ inches})}{288} = \text{the number of square feet of roof covered.}$$

Weight of slate of various lengths and thicknesses required for one square of roof:

Length in Inches.	Weight in Pounds per Square for the Thickness.							
	1/8″	3-16″	1/4″	3/8″	1/2″	5/8″	3/4″	1″
12	483	724	967	1450	1936	2419	2902	3872
14	460	688	920	1379	1842	2301	2760	3683
16	445	667	890	1336	1784	2229	2670	3567
18	434	650	869	1303	1740	2174	2607	3480
20	425	637	851	1276	1704	2129	2553	3408
22	418	626	836	1254	1675	2093	2508	3350
24	412	617	825	1238	1653	2066	2478	3306
26	407	610	815	1222	1631	2039	2445	3263

The weights given above are based on the number of slate required for one square of roof, taking the weight of a cubic foot of slate at 175 pounds.

Pine Shingles.

Number and weight of pine shingles required to cover one square of roof:

Number of Inches Exposed to Weather.	Number of Shingles per Square of Roof.	Weight in Pounds of Shingle on One-square of Roofs.	Remarks.
4	900	216	The number of shingles per square is for common gable-roofs. For hip-roofs add five per cent. to these figures. The weights per square are based on the number per square.
4½	800	192	
5	720	173	
5½	655	157	
6	600	144	

(Courtesy of William Kent, A. M., M. E.)

WEIGHTS OF SQUARE AND ROUND BARS OF WROUGHT IRON IN POUNDS PER LINEAL FOOT.

Iron weighing 480 lbs. per cubic foot. For steel add 2 per cent.

Thickness or Diameter in Inches.	Weight of Square Bar One Foot Long.	Weight of Round Bar One Foot Long.	Thickness or Diameter in Inches.	Weight of Square Bar One Foot Long.	Weight of Round Bar One Foot Long.	Thickness or Diameter in Inches.	Weight of Square Bar One Foot Long.	Weight of Round Bar One Foot Long.
0			11/16	24.08	18.91	⅜	96.30	75.64
1/16	.013	.010	¾	25.21	19.80	7/16	98.55	77.40
⅛	.052	.041	13/16	26.37	20.71	½	100.8	79.19
3/16	.117	.092	⅞	27.55	21.64	9/16	103.1	81.00
¼	.208	.164	15/16	28.76	22.59	⅝	105.5	82.83
5/16	.326	.256	3	30.00	23.56	11/16	107.8	84.69
⅜	.469	.368	1/16	31.26	24.55	¾	110.2	86.56
7/16	.638	.501	⅛	32.55	25.57	13/16	112.6	88.45
½	.833	.654	3/16	33.87	26.60	⅞	115.1	90.36
9/16	1.055	.828	¼	35.21	27.65	15/16	117.5	92.29
⅝	1.302	1.023	5/16	36.58	28.73	6	120.0	94.25
11/16	1.576	1.237	⅜	37.97	29.82	⅛	125.1	98.22
¾	1.875	1.473	7/16	39.39	30.94	¼	130.2	102.3
13/16	2.201	1.728	½	40.83	32.07	⅜	135.5	106.4
⅞	2.552	2.004	9/16	42.30	33.23	½	140.8	110.6
15/16	2.930	2.301	⅝	43.80	34.40	⅝	146.3	114.9
1	3.333	2.618	11/16	45.33	35.60	¾	151.9	119.3
1/16	3.763	2.955	¾	46.88	36.82	⅞	157.6	123.7
⅛	4.219	3.313	13/16	48.45	38.05	7	163.3	128.3
3/16	4.701	3.692	⅞	50.05	39.31	⅛	169.2	132.9
¼	5.208	4.091	15/16	51.68	40.59	¼	175.2	137.6
5/16	5.742	4.510	4	53.33	41.89	⅜	181.3	142.4
⅜	6.302	4.950	1/16	55.01	43.21	½	187.5	147.3
7/16	6.888	5.410	⅛	56.72	44.55	⅝	193.8	152.2
½	7.500	5.890	3/16	58.45	45.91	¾	200.2	157.2
9/16	8.138	6.392	¼	60.21	47.29	⅞	206.7	162.4
⅝	8.802	6.913	5/16	61.99	48.69	8	213.3	167.6
11/16	9.492	7.455	⅜	63.80	50.11	¼	226.9	178.2
¾	10.21	8.018	7/16	65.64	51.55	½	240.8	189.2
13/16	10.95	8.601	½	67.50	53.01	¾	255.2	200.4
⅞	11.72	9.204	9/16	69.39	54.50	9	270.0	212.1
15/16	12.51	9.828	⅝	71.30	56.00	¼	285.2	224.0
2	13.33	10.47	11/16	73.24	57.52	½	300.8	236.3
1/16	14.18	11.14	¾	75.21	59.07	¾	316.9	248.9
⅛	15.05	11.82	13/16	77.20	60.63	10	333.3	261.8
3/16	15.95	12.53	⅞	79.22	62.22	¼	350.2	275.1
¼	16.88	13.25	15/16	81.26	63.82	½	367.5	288.6
5/16	17.83	14.00	5	83.33	65.45	¾	385.2	302.5
⅜	18.80	14.77	1/16	85.43	67.10	11	403.3	316.8
7/16	19.80	15.55	⅛	87.55	68.76	¼	421.9	331.3
½	20.83	16.36	3/16	89.70	70.45	½	440.8	346.2
9/16	21.89	17.19	¼	91.88	72.16	¾	460.2	361.4
⅝	22.97	18.04	5/16	94.08	73.89	12	480.	377.

(Courtesy of William Kent, A. M., M. E.)

CYLINDRICAL VESSELS, TANKS, CISTERNS, ETC.

Diameter in Feet and Inches, Area in Square Feet, and U. S. Gallons Capacity for One Foot in Depth.

$$1 \text{ gallon} = 231 \text{ cubic inches} = \frac{1 \text{ cubic foot}}{7.4805} = 0.13368 \text{ cubic feet.}$$

Diam.	Area.	Gals.	Diam.	Area.	Gals.	Diam.	Area.	Gals.
Ft. In.	Sq. ft.	1 foot depth.	Ft. In.	Sq. ft.	1 foot depth.	Ft. In.	Sq. ft.	1 foot depth.
1	.785	5 87	5 8	25.22	188 66	19	283.53	2120.9
1 1	.922	6.89	5 9	25.97	194.25	19 3	291.04	2177.1
1 2	1.069	8.00	5 10	26 73	199.92	19 6	298.65	2234.0
1 3	1.227	9.18	5 11	27.49	205.67	19 9	306.35	2291.7
1 4	1.396	10.44	6	28.27	211.51	20	314.16	2350.1
1 5	1.576	11.79	6 3	30.68	229.50	20 3	322.06	2409.2
1 6	1.767	13.22	6 6	33.18	248.23	20 6	330.06	2469.1
1 7	1.969	14.73	6 9	35.78	267.69	20 9	338.16	2529.6
1 8	2.182	16.32	7	38.48	287.88	21	346.36	2591.0
1 9	2.405	17.99	7 3	41.28	308.81	21 3	354.66	2653.0
1 10	2.640	19.75	7 6	44.18	330.48	21 6	363.05	2715.8
1 11	2.885	21.58	7 9	47.17	352.88	21 9	371.54	2779.3
2	3.142	23.50	8	50.27	376.01	22	380.13	2843.6
2 1	3.409	25.50	8 3	53.46	399.88	22 3	388.82	2908.6
2 2	3.687	27.58	8 6	56.75	424.48	22 6	397.61	2974.3
2 3	3.976	29.74	8 9	60.13	449.82	22 9	406.49	3040.8
2 4	4.276	31.99	9	63 62	475.89	23	415.48	3108.0
2 5	4.587	34 31	9 3	67.20	502.70	23 3	424.56	3175.9
2 6	4.909	36.72	9 6	70.88	530 24	23 6	433.74	3244.6
2 7	5.241	39.21	9 9	74.66	558.51	23 9	443 01	3314.0
2 8	5.585	41.78	10	78.54	587.52	24	452.39	3384.1
2 9	5.940	44.43	10 3	82.52	617.26	24 3	461.86	3455.0
2 10	6.305	47.16	10 6	86.59	647.74	24 6	471.44	3526.6
2 11	6.681	49.98	10 9	90.76	678.95	24 9	481.11	3598.9
3	7.069	52.88	11	95.03	710.90	25	490.87	3672.0
3 1	7.467	55.86	11 3	99.40	743.58	25 3	500.74	3745.8
3 2	7.876	58.92	11 6	103.87	776.99	25 6	510.71	3820 3
3 3	8.296	62.06	11 9	108.43	811.14	25 9	520.77	3895.6
3 4	8.727	65.28	12	113.10	846.03	26	530.93	3971.6
3 5	9.168	68.58	12 3	117.86	881.65	26 3	541.19	4048.4
3 6	9.621	71.97	12 6	122.72	918.00	26 6	551.55	4125.9
3 7	10.085	75.44	12 9	127.68	955.09	26 9	562.00	4204.1
3 8	10.559	78.99	13	132.73	992.91	27	572.56	4283.0
3 9	11.045	82 62	13 3	137.89	1031.5	27 3	583.21	4362.7
3 10	11.541	86.33	13 6	143.14	1070.8	27 6	593.96	4443.1
3 11	12.048	90.13	13 9	148.49	1110.8	27 9	604.81	4524.3
4	12.566	94.00	14	153.94	1151.5	28	615.75	4606.2
4 1	13.095	97.96	14 3	159.48	1193.0	28 3	626.80	4688.8
4 2	13.635	102.00	14 6	165.13	1235.3	28 6	637.94	4772.1
4 3	14.186	106.12	14 9	170.87	1278.2	28 9	649.18	4856.2
4 4	14.748	110.32	15	176.71	1321.9	29	660.52	4941.0
4 5	15.321	114.61	15 3	182.65	1366.4	29 3	671.96	5026.6
4 6	15.90	118.97	15 6	188 69	1411.5	29 6	683.49	5112.9
4 7	16.50	123.42	15 9	194.83	1457.4	29 9	695.13	5199.9
4 8	17.10	127.95	16	201.06	1504.1	30	706.86	5287.7
4 9	17.72	132.56	16 3	207.39	1551.4	30 3	718.69	5376.2
4 10	18.35	137.25	16 6	213 82	1599.5	30 6	730.62	5465 4
4 11	18.99	142 02	16 9	220.35	1648.4	30 9	742.64	5555.4
5	19.63	146.88	17	226.98	1697.9	31	754.77	5646.1
5 1	20.29	151.82	17 3	233.71	1748.2	31 3	766.99	5737.5
5 2	20.97	156.83	17 6	240.53	1799.3	31 6	779.31	5829.7
5 3	21.65	161.93	17 9	247.45	1851.1	31 9	791.73	5922.6
5 4	22.34	167.12	18	254 47	1903.6	32	804 25	6016.2
5 5	23.04	172.38	18 3	261.59	1956.8	32 3	816.86	6110.6
5 6	23.76	177.72	18 6	268.80	2010.8	32 6	829.58	6205.7
5 7	24.48	183.15	18 9	276.12	2065.5	32 9	842.39	6301.5

(Courtesy of William Kent, A. M., M. E.)

GALLONS AND CUBIC FEET.

United States Gallons in a given Number of Cubic Feet.

1 cubic foot = 7.480519 U. S. gallons; 1 gallon = 231 cu. in. = .13368056 cu. ft.

Cubic Ft.	Gallons.	Cubic Ft.	Gallons.	Cubic Ft.	Gallons.
0.1	0.75	50	374.0	8,000	59,844.2
0.2	1.50	60	448.8	9,000	67,324.7
0.3	2.24	70	523.6	10,000	74,805.2
0.4	2.99	80	598.4	20,000	149,610.4
0.5	3.74	90	673.2	30,000	224,415.6
0.6	4.49	100	748.0	40,000	299,220.8
0.7	5.24	200	1,496.1	50,000	374,025.9
0.8	5.98	300	2,244.2	60,000	448,831.1
0.9	6.73	400	2,992.2	70,000	523,636.3
1	7.48	500	3,740.3	80,000	598,441.5
2	14.96	600	4,488.3	90,000	673,246.7
3	22.44	700	5,236.4	100,000	748,051.9
4	29.92	800	5,984.4	200,000	1,496,103.8
5	37.40	900	6,732.5	300,000	2,244,155.7
6	44.88	1,000	7,480.5	400,000	2,992,207.6
7	52.36	2,000	14,961.0	500,000	3,740,259.5
8	59.84	3,000	22,441.6	600,000	4,488,311.4
9	67.32	4,000	29,922.1	700,000	5,236,363.3
10	74.80	5,000	37,402.6	800,000	5,984,415.2
20	149.6	6,000	44,883.1	900,000	6,732,467.1
30	224.4	7,000	52,363.6	1,000,000	7,480,519.0
40	299.2				

Cubic Feet in a given Number of Gallons.

Gallons.	Cubic Ft.	Gallons.	Cubic Ft.	Gallons.	Cubic Ft.
1	.134	1,000	133.681	1,000,000	133,680.6
2	.267	2,000	267.361	2,000,000	267,361.1
3	.401	3,000	401.042	3,000,000	401,041.7
4	.535	4,000	534.722	4,000,000	534,722.2
5	.668	5,000	668.403	5,000,000	668,402.8
6	.802	6,000	802.083	6,000,000	802,083.3
7	.936	7,000	935.764	7,000,000	935,763.9
8	1.069	8,000	1,069.444	8,000,000	1,069,444.4
9	1.203	9,000	1,203.125	9,000,000	1,203,125.0
10	1.337	10,000	1,336.806	10,000,000	1,336,805.6

(Courtesy of William Kent, A. M., M. E.)

CONTENTS IN CUBIC FEET AND U. S. GALLONS OF PIPES AND CYLINDERS OF VARIOUS DIAMETERS AND ONE FOOT IN LENGTH.

1 gallon = 231 cubic inches. 1 cubic foot = 7.4805 gallons.

Diameter in Inches.	For 1 Foot in Length.		Diameter in Inches.	For 1 Foot in Length.		Diameter in Inches.	For 1 Foot in Length.	
	Cubic Ft. also Area in Sq. Ft.	U. S. Gals., 231 Cu. In.		Cubic Ft. also Area in Sq. Ft.	U. S. Gals., 231 Cu. In.		Cubic Ft. also Area in Sq. Ft.	U. S. Gals., 231 Cu. In.
¼	.0003	.0025	6¾	.2485	1.859	19	1.969	14.73
5-16	.0005	.004	7	.2673	1.999	19½	2.074	15.51
⅜	.0008	.0057	7¼	.2867	2.145	20	2.182	16.32
7-16	.001	.0078	7½	.3068	2.295	20½	2.292	17.15
½	.0014	.0102	7¾	.3276	2.45	21	2.405	17.99
9-16	.0017	.0129	8	.3491	2.611	21½	2.521	18.86
⅝	.0021	.0159	8¼	.3712	2.777	22	2.640	19.75
11-16	.0026	.0193	8½	.3941	2.948	22½	2.761	20.66
¾	.0081	.0230	8¾	.4176	3.125	23	2.885	21.58
13-16	.0036	.0269	9	.4418	3.305	23½	3.012	22.53
⅞	.0042	.0312	9¼	.4667	8.491	24	3.142	23.50
15-16	.0048	.0359	9½	.4922	3.682	25	3.409	25.50
1	.0055	.0408	9¾	.5185	8.879	26	3.687	27.58
1¼	.0085	.0638	10	.5454	4.08	27	3.976	29.74
1½	.0123	.0918	10¼	.5730	4.286	28	4.276	31.99
1¾	.0167	.1249	10½	.6013	4.498	29	4.587	34.31
2	.0218	.1632	10¾	.6303	4.715	30	4.909	36.72
2¼	.0276	.2066	11	.66	4.937	31	5.241	39.21
2½	.0341	.2550	11¼	.6903	5.164	32	5.585	41.7S
2¾	.0412	.3085	11½	.7213	5.396	33	5.940	44.43
3	.0491	.3672	11¾	.7530	5.633	84	6.305	47.16
3¼	.0576	.4309	12	.7854	5.875	35	6.681	49.98
3½	.0668	.4998	12½	.8522	6.375	36	7.069	52.88
3¾	.0767	.5738	13	.9218	6.895	37	7.467	55.86
4	.0878	.6528	13½	.994	7.436	38	7.876	58.92
4¼	.0985	.7369	14	1.069	7.997	39	8.296	62.06
4½	.1104	.8263	14½	1 147	8.578	40	8.727	65.28
4¾	.1231	.9206	15	1.227	9.180	41	9.168	68.58
5	.1364	1.020	15½	1.310	9.801	42	9.621	71.97
5¼	.1503	1.125	16	1.396	10.44	43	10.085	75.44
5½	.1650	1.234	16½	1.485	11.11	44	10.559	78.99
5¾	.1803	1.349	17	1.576	11.79	45	11.045	82.62
6	.1963	1.469	17½	1.670	12.49	46	11.541	86.33
6¼	.2131	1.594	18	1.768	13.22	47	12.048	90.13
6½	.2304	1.724	18½	1.867	13.96	48	12.566	94.00

To find the capacity of pipes greater than the largest given in the table, look in the table for a pipe of one half the given size, and multiply its capacity by 4; or one of one third its size, and multiply its capacity by 9, etc.

To find the *weight* of water in any of the given sizes multiply the capacity in cubic feet by 62¼ or the gallons by 8⅓, or, if a closer approximation is required, by the weight of a cubic foot of water at the actual temperature in the pipe.

Given the dimensions of a cylinder in inches, to find its capacity in U. S. gallons: Square the diameter, multiply by the length and by .0034. If d = diameter, l = length, gallons = $\frac{d^2 \times .7854 \times l}{231} = .0034d^2l$.

(Courtesy of William Kent, A. M., M. E.)

Contents in Feet of Joists, Scantling, and Timber.

Length in Feet.

Size.	12	14	16	18	20	22	24	26	28	30
	Feet Board Measure.									
2 × 4	8	9	11	12	13	15	16	17	19	20
2 × 6	12	14	16	18	20	22	24	26	28	30
2 × 8	16	19	21	24	27	29	32	35	37	40
2 × 10	20	23	27	30	33	37	40	43	47	50
2 × 12	24	28	32	36	40	44	48	52	56	60
2 × 14	28	33	37	42	47	51	56	61	65	70
3 × 8	24	28	32	36	40	44	48	52	56	60
3 × 10	30	35	40	45	50	55	60	65	70	75
3 × 12	36	42	48	54	60	66	72	78	84	90
3 × 14	42	49	56	63	70	77	84	91	98	105
4 × 4	16	19	21	24	27	29	32	35	37	40
4 × 6	24	28	32	36	40	44	48	52	56	60
4 × 8	32	37	43	48	53	59	64	69	75	80
4 × 10	40	47	53	60	67	73	80	87	93	100
4 × 12	48	56	64	72	80	88	96	104	112	120
4 × 14	56	65	75	84	93	103	112	121	131	140
6 × 6	36	42	48	54	60	66	72	78	84	90
6 × 8	48	56	64	72	80	88	96	104	112	120
6 × 10	60	70	80	90	100	110	120	130	140	150
6 × 12	72	84	96	108	120	132	144	156	168	180
6 × 14	84	98	112	126	140	154	168	182	196	210
8 × 8	64	75	85	96	107	117	128	139	149	160
8 × 10	80	93	107	120	133	147	160	173	187	200
8 × 12	96	112	128	144	160	176	192	208	224	240
8 × 14	112	131	149	168	187	205	224	243	261	280
10 × 10	100	117	133	150	167	183	200	217	233	250
10 × 12	120	140	160	180	200	220	240	260	280	300
10 × 14	140	163	187	210	233	257	280	303	327	350
12 × 12	144	168	192	216	240	264	288	312	336	360
12 × 14	168	196	224	252	280	308	336	364	392	420
14 × 14	196	229	261	294	327	359	392	425	457	490

(Courtesy of William Kent, A. M., M. E.)

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